ELECTRICAL ENGINEERING

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The Cover: Pietro Montana, noted Italian sculptor, presenting his excellent rendering of a bust of Guglielmo Marconi to AIEE President Morris D. Hooven at a ceremony in the lobby of the Engineering Societies Building, New York, N. Y.

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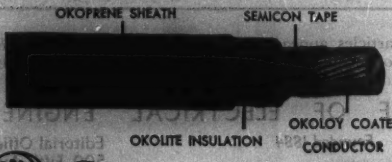
Why Okoloy conductor coating outlasts "tinning" 2 to 1

The conductors above are immersed in a solution of sulphuric acid. Bare copper conductors are quickly attacked by corrosive chemicals such as sulphur acids formed when moisture combines with sulphur and sulphur compounds frequently used in the vulcanization of rubber insulations. The conductor coating must, therefore, be highly resistant to it.



The copper wire on the left is coated with tin, the most commonly-used conductor coating material. The acid attacks it immediately. The other copper wire, unaffected by the acid, is coated with Okoloy. Okoloy, a virtually pure lead coating, has been used by Okonite since 1928 to coat all copper conductors for rubber-insulated cables. Of all the common metals, lead is least affected by sulphuric acid and other corrosive chemicals. *Okoloy outlasts even the best "tinning" at least 2 to 1.*

* * *

Next time you buy a rubber-insulated cable, *make sure* the insulation and conductor are protected by Okoloy conductor coating—*not* tin.

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Okolite-Okoprene cables are made by the strip-insulating process

OKONITE *insulated cables*

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HIGHLIGHTS.....

A New 5-Kv 50,000-Kva De-ion Air Circuit Breaker. An outstanding feature of this new breaker is its smaller and lighter arc chute, which has improved interrupting performance and increased insulation strength. Performance of the breaker has been proved by extensive tests under many conditions (*pp. 1072–6*).

Load-Phase and Load-Phase Tie-Line Energy Control of Power Systems. This article combines the contents of two AIEE papers recently presented by this author. The control system was originated in France and is adaptable for use on a single system or on several interconnecting systems (*pp. 1068–9*).

Laminates for Printed Circuits. Printed circuits using metal-clad laminates as a base are being used in many military and civilian applications at the present time, and many new applications are being studied. Ingredients and procedures for manufacturing are discussed (*pp. 1092–3*).

Surface Emissivity as a Factor in Appliance Design. An often misunderstood fundamental in heat transfer is the property of emissivity. That it should not be overlooked in electric-appliance design, is pointed out by the examples given in this article (*pp. 1054–8*).

An Experimental Transistorized Calculator. A new calculator, using 2,100 transistors and no vacuum tubes, has been developed and tested. Results have shown high reliability coupled with the advantages of compact size and low power requirements (*pp. 1044–8*)

Obligations of Engineering Management in a Large Decentralized Company. With our increasingly complex technology and the trend toward decentralization, management's problems have become more numerous and complicated. The objectives and obligations of management in a large company are discussed in detail (*pp. 1039–43*).

Design of Electric Systems in Jet Fighter Aircraft. The design of an electric system has always been a challenging task. This is especially true in jet fighter aircraft, where space is at such a premium and reliability is vital. The design engineer's problems and his approach to these problems are outlined (*pp. 1050–2*).

Broad Survey of Engineering Profession Essential. A number of important problems face the engineering profession as a whole, both in industry and on the educational level. A proposal for a detailed, inclusive appraisal of the profession is presented (*pp. 1085–7*).

A Simplified Mathematical Approach to Hysteresis Losses. A simple method of dealing with hysteresis in magnetic-circuit theory is described. Through the use of complex quantities and neglecting the effects of nonlinearity, an elliptical approximation to a hysteresis loop is developed (*p. 1060*).

The photograph of the **F-102A** was incorrectly identified on page 932, October, *Electrical Engineering*. This plane was built by the Convair Division of General Dynamics Corporation. It is packed with the latest electronic gear and is designed to intercept enemy bombers at stratospheric altitudes at any time of the day or night, in any kind of weather. Maximum speed is over Mach 1 in level flight. The engine is a Pratt and Whitney J-57 Turbojet. Other specifications are classified military security information.

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The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Reliability in Complex Electronic Equipment. Component reliability is of prime importance in electronic equipment, especially as the equipment becomes more complex. A study has shown that the component failure rate may be reduced by more effective quality control and testing procedures. The use of plug-in subassemblies to minimize maintenance problems is also discussed (*pp. 1062–5*).

New NEMA Standards for D-C Motors and Generators. A detailed description of the new suggested standards and the reasons for the changes from the present standards are given. It is believed that the new simplified standards represent a definite improvement and are realistic in the light of today's requirements (*pp. 1080–5*).

National Bureau of Standards Preferred Circuits Program. Standardization, long common to electronic components, is now being attempted with electronic circuits. Strides made in this relatively new field by the National Bureau of Standards, as well as the problems encountered, are discussed (*pp. 1088–90*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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Obligations of Engineering Management in a Large Decentralized Company

C. H. LINDER
MEMBER AIEE

The obligations of engineering management and the methods for meeting these obligations are outlined. The author also discusses the relationships between marketing, product engineering, and manufacturing.

BUSINESSMEN EVERYWHERE are looking forward to a strong and growing economy for the United States. It is obvious that technological progress will be an inherent part of that economic growth, and that extraordinary developments will be made in many technological fields. However, with the rapid growth of technology and economic development, certain areas of incompatibility must be taken into account. On the one hand there is the explosive rate at which technology is expanding, both in volume and in complexity. This acts as a sort of splintering force, tending to drive all knowledge, understanding, and skill into more and more specialized compartments, making it more difficult either for the compartments to understand one another, or for the public to understand them. On the other hand, there is the summation of several social and economic forces which have been growing during the past 25 years. Government controls, large labor organizations, and the concept of corporate citizenship are symptomatic of changes in the business climate, which add up to an adhesive force that tends to decompartmentalize our economy and bring about a much closer intermingling among all the functions of a business and all the segments of the public. The problem is to control and direct these forces so that each contributes its utmost toward the economic and technological expansion envisioned.

All of us, in our everyday lives as members of the general public, are heading toward a future in which technology plays a more and more important part, and that technology is getting steadily more complex and hard to understand. Those engaged in engineering, manufacturing, and marketing, which are the three functions of a business where the application of technology based on the physical sciences is a predominant factor, must see to it that technology is exploited in the best interests of the public. In order to do this, technology must be interpreted effectively among ourselves and to the public. We are not insulated to the degree we may once have been from the opinions of the public, opinions expressed as reactions of customers or voting citizens.

We are involved in an exceedingly elaborate network of relationships which are certainly not static but highly dynamic, and which deal with extremely complex and abstract subject matter. The danger of missing our objectives is always at hand, and the chances of confusion and misunderstanding are far too numerous for comfort. Anyone who does not formulate his obligations clearly and devise a plan for meeting them will find that others are quite ready to do so for him and are, moreover, equally ready to judge his performance not on his terms, but on their own.

THE OBLIGATIONS OF A BUSINESS

WITH THIS BACKGROUND in mind, the subject of obligations, both for business in general and for the specific function of engineering management, should be examined. This examination will be conducted in terms of a large decentralized manufacturing company; however, much of what is found will be sufficiently fundamental in nature to be generally valid for all business. Two statements of the objectives of the General Electric Company have been enunciated by its president, Mr. Cordiner. The company is a large one, but with regard to size Mr. Cordiner has said, "The objective here is to make size, as such, an element of constructive strength, to the end that bigness of itself becomes a source of extra or plus contributions to our share-owners, to our employees, to the communities, in which we manufacture and do business, and to the country as a whole."

With regard to decentralized management, "The goal is to achieve, on time, challenging and difficult-to-attain objectives of the business in the balanced best interests of customers, employees, share-owners, suppliers, and the public and its representative, Government."

Both of these statements contain elements of obligations, not only to the specific interests of those participating directly in the enterprise, but also to the general welfare of the culture which permits that enterprise to exist and is, therefore, affected by it. Further examination will show that the ethics involved in meeting these obligations are independent of size or organizational characteristics. Size is important because it relates to the impact an obligation will carry; decentralization is important because it may alter radically the relationships and techniques concerned with meeting an obligation. But neither has any fundamental effect on the nature of the obligation, or the action required to meet it.

These objectives may be translated into some generalized obligations of a business. The fact that most, or all, of these obligations are familiar will demonstrate their general applicability; but, more important, they will serve as a

Revised text of a conference paper presented at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955, and recommended for publication by the AIEE Committee on Management.

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basis for discussion of the specific obligations of engineering management.

From these two statements of objectives for a large decentralized company, five specific areas of obligation can be outlined: (1) to shareholders, (2) to employees, (3) to vendors, (4) to customers, and (5) to the public as a whole. The main objectives can also be amplified in terms of each specific area. Management, of course, is obligated to its shareholders to operate the business profitably. If the business is to grow and prosper, not only should a proper balance between a fair return on a short-range basis and a wise reinvestment in strength for the future be maintained, but also the affairs of the business should be conducted in such a manner as to build ready public acceptance and even prestige for its achievements.

Certainly the subject of the obligations of business to its employees has been expounded exhaustively by organized labor, by management, and by academicians of every shade of neutrality. These obligations may be listed as follows:

1. An opportunity to do good work.
2. Good facilities.
3. An appropriate reward for good performance in the form of compensation, recognition, and work security.

Toward vendors, it would seem that business ought to discharge the following obligations: first, to provide an opportunity to participate in the business through the vendor's contribution to the end product; and second, just as with the employee, to reward the vendor's contribution through appropriate compensation, co-operation, recognition, and work security.

The obligations of a business to its customers, like those to its employees, have been extensively defined on a continuing basis, usually by the customer. However, if business were to distill a simplified statement of these obligations it would probably be to anticipate or meet promptly the customer's requirements with a product which will be desirable in terms of price, appearance, technological function, reliability, and quality.

The obligations of a business to the public are:

1. To contribute in every way to economic progress, especially in terms of employment, standard of living, and national strength.
2. To make its contributions within the spirit, as well as the letter, of rules of conduct for individuals and enterprises.
3. To promote, preserve, and protect the rights or values of others while carrying out the interests of the individual enterprise.

THE OBLIGATIONS OF A BUSINESS FUNCTION

A GREAT DEAL OF TIME could be spent in further examination of these general areas of obligation, but in the end little more would be accomplished than the comfortably virtuous feeling of having seen a duty and being ready, able, and anxious to do it. Far too often we have confined our thinking to general terms, with the result that no matter how willing we may have been to do our duty, we have been neither ready nor able. The fact is that only the business entity itself can directly fulfill these general obligations. Each of the individual functions of a business, while it shares the general obligations with all other functions, must primarily make its contributions directly to the business in quite specific functional terms. It is the summation of the direct functional contributions to the business, properly balanced, which enables the business entity to assume and discharge its general obligations. This is another way of saying that before the shareholders can have any sort of return, the employee any kind of job, the customer any product, the vendor any market, or the public anything to judge, somebody must successfully design, produce, and sell something. Therefore, engineering management, like other functional management, has a dual responsibility: (1) to optimize its direct functional contribution to the business, and (2) to integrate its functional contribution with all other contributions in such a way that the general obligations of the business are met. Certainly these two facets of engineering management responsibility are not mutually exclusive, but it is common practice to concentrate on the integration facet as if it were independent. Some time should be spent in considering the responsibility for making the direct functional contribution, without which it is futile to discuss general obligations.

OBLIGATIONS OF THE ENGINEERING FUNCTION

THE WORD "ENGINEERING" in our term "engineering management" at this point should be changed to the term "product engineering." Product engineering designates what those in the manufacturing industries generally have in mind when they speak of the engineering function; that is, the application of theories and factual knowledge about materials and natural phenomena, together with the industrial arts, to the development of products to fulfill human needs. This definition will be helpful in the examination of the obligations which product engineering management must meet in order to make its direct functional contribution to the business entity.

DETERMINING CHARTER

PRODUCT ENGINEERING MANAGEMENT should first determine its field of operation; i.e., it should have an operating charter which describes the area in which the contribution will be made. The engineering charter has often been an unwritten instrument like the British Constitution; but it should be so clearly thought out that it can, if necessary, be expressed promptly in writing. The charter should describe the activities which will be engaged in, such as design or development and research, and the subjects to which these activities will be directed, such as prime movers, lighting, or locomotives. Thus, the charter will provide for continuing determinations of human needs and of specific products and technologies to fulfill them. It will also recognize that new technologies may develop which can be translated into new ways of fulfilling human needs; that is, into new and perhaps unforeseen products within the original statement of activities and subjects of activities. The charter not only describes the function which the engineering component performs in the current business of the enterprise, but also outlines the surrounding

territory into which the enterprise can grow through engineering contributions.

The specific elements contained in such a charter will undoubtedly vary from business to business and may include the following:

1. The product engineering contribution, in terms of product determinations to be made.
2. The segments of the business entity and of the public to be served directly.
3. The fields of activity required to make that contribution.
4. The business resources required to make that contribution.
5. The general features of the organization which might be employed.
6. The rules and standards which would govern the product engineering activity.

The charter thus provides the real basis for initial determination of the work to be done and for continual review of operations.

Particular care should be used in defining engineering contributions. Engineering contributions could be defined in terms of specific products in which a business now engages. If this approach were followed, the business might not be prepared to make an enduring contribution. In the appliance business, for example, more than half of the major appliances now offered have been introduced since World War II. Moreover, one third of the lines offered prior to the war are no longer manufactured. The charter should, therefore, be developed in a permissive way, outlining an enduring area of activity or service, and should not be restricted to only those particular products which now are attractive from a business standpoint.

The engineering charter should also avoid limiting the goods or services to the present technology. The lighting business may be used as an example. Prior to 1815 anyone in this business would have been interested in either obtaining, rendering, or trading spermaceti whale oil, or making or trading lamp fixtures for burning this oil. But the succeeding years have seen the technology of artificial lighting range through candles, kerosene, gas, the carbon arc, the incandescent filament, and fluorescence, with electroluminescence perhaps available in the near future. It is true, of course, that the introduction of each new kind of technology did not immediately replace the old. Some have now been replaced, however, and the growth of a business based on any one of the technologies would have been limited by the improved technologies which came along to take over growth areas of the market. In order that a business may have the freedom necessary to undertake technical work leading to the introduction of new technology in terms of products in the field of its business interest, it seems essential that it develop its charter and scope in these broad terms. Since technology and business are dynamic, it is vital that we think of the charter as something which is not static but a living, breathing entity. Thus, just as we examine the Constitution of the United States on occasion for the necessity of adding amendments, we must examine the charter laid down for engineering organizations in a business enterprise.

CONTRIBUTING TO PRODUCT PLANNING

THE SECOND OBLIGATION of product engineering management is to contribute to the derivation of a product plan. Product planning may be an elaborate process or a relatively simple one, depending again on the nature of the business. But it is essential to recognize that each function of the business must make a contribution, irrespective of where the spearheading responsibility may be assigned within a particular business entity. The product planning process involves complex interfunctional relationships, but it can be described fairly accurately as the time when the team gets together to decide on its common objectives and agrees on the individual contributions of each of its members. The contribution each function will make becomes clear when the common objective toward which all functions work is determining sound and specific answers to the three vital business questions:

1. What are we going to sell?
2. To whom?
3. Why will he buy it from us?

Answers to these three questions, although at times they may be tentative, focus sharply on things which are vital activities to be done in each of the key areas.

DERIVING A TECHNICAL PLAN

WITH A PRODUCT PLAN ESTABLISHED, the next obligation of product engineering management, which must be met independently, is the derivation of a technical plan. This process may be summarized as follows:

1. Analyze the product plan to determine the work which needs to be done.
2. Determine the technologies and the specific projects necessary to get that work done.
3. Select the areas of work and the projects sufficiently important to the business to invest in them.
4. Assign the responsibilities and obtain the facilities to carry out this work, and review and evaluate the progress which results.

Although each of these steps is superficially self-explanatory, a great deal could be written on the methods of carrying them out and on the importance of not blurring one with another in our thinking. The first and second steps will be discussed in detail.

It is quite surprising and disquieting to realize the number of times we fail to do a good job of deriving the technology and the technical work needed to implement a product plan. There should be a technical plan as complete and as well thought out as the brick and mortar and financial details prepared when a capital expenditure is contemplated. To the extent that this goal is not achieved the penalty will be paid in excess costs, missed schedules, and loss of competitive advantage.

As a result of a good technical plan, two more important dividends can also be achieved. The critical technical problems can be recognized and the skills necessary to

solve them can be catalogued. Critical technical problems may be defined as those which affect the market performance of the products of a business and whose solution depends basically upon results from technical work. Some of these problems will not be completely solved in the foreseeable future; only improvements toward solution can be expected. These we may call "continuing critical technical problems." Others are transient in nature and will be solved completely, or will face us only for a short time. The process of planning technical work involves listing of these critical technical problems, both continuing and transient, and thus provides an opportunity to concentrate engineering effort where it may prove to be of greatest impact and effectiveness.

ORGANIZING TO EXECUTE THE TECHNICAL PLAN

THE OBLIGATION of product engineering management is to organize to make its functional contribution. The following is a suggested outline for this organizing process:

1. Determining the broad categories of work needed to make the required contribution.
2. Dividing those categories into work elements.
3. Combining those elements into positions which will continuously challenge, but not exceed, the capabilities of competent available people.
4. Combining the positions into organization components.

The process here offered is not essentially new, except perhaps in that it has been thought out and written down, but it appears to have valuable applicability in general. Of particular importance is the fact that the foundation of the organizing process depends on the result of the technical plan, i.e., determining the technical work to be done, and the technology and the skills needed to do it. Both plans are needed for success, yet how often has organization been accomplished practically *in vacuo* with respect to a technical plan?

DEFINING RELATIONSHIPS

CLOSELY RELATED TO ORGANIZATION is the obligation incumbent on product engineering management to define its relationships with other functions, particularly with manufacturing and marketing. It is evident that the relationships are complex; and it is known that eventually a successful steady-state condition will exist. But it is also evident that both new technology and demands of the market place can introduce disturbing transients in these relationships. In modern times it is essential that a successful working relationship be reached as promptly as possible; and this imposes the obligation of defining, in specific form, elements and areas of responsibility which have previously been set up largely by instinct and the cut-and-try method. It is rather a new field, and one which offers great promise, coupled with a great deal of hard work. It should be recognized that there are two kinds of responsibility each function must discharge: first, the responsibility to decide certain things in the interests of the business enterprise; second, the responsibility to inform others making their decisions, and to seek information from others when making decisions for which we carry the responsibility.

Perhaps the simplest statement of the basic relationship among marketing, product engineering, and manufacturing is this:

1. Marketing is responsible and accountable for deciding product requirements which will fulfill the needs of the market place.
2. Product engineering is responsible and accountable for the extent to which specific products made to its designs match the technical and economic requirements of the market.
3. Manufacturing is responsible and accountable for the extent to which the products produced match the specifications drawn by the product engineers and for meeting permissible production costs.

In addition to these accountabilities, each function has responsibilities to inform and to seek information from the others as necessary to the over-all functioning of all three. Thus, what marketing decides to offer is contingent upon what product engineering can design and manufacturing produce. Similarly product engineering, starting with a market requirement, specifies what is to happen to yield a product, although it does not specify how this is to be done. How it is made to happen and at what cost is manufacturing's contribution. But all three must freely inform and be informed by the others in order to end up with mutually practicable contributions.

An extension of this matter of informing and being informed constitutes another important obligation of engineering management, i.e., to pass on technical information. It is a very important obligation today, when the predicted demands on our economy so clearly and substantially exceed the expected supply of trained people. Communication of technical information is a powerful tool for meeting this challenge. Just as it is possible, through the use of electric power, to concentrate the muscular equivalent of many thousands of men on one job, so it is possible through the use of words, pictures, and numbers, to bring to bear on a given problem the experience and thinking of many thousands of men, both living and dead. Moreover, technology needs at least occasional interchange, in order that it may improve and adapt itself to its ever-changing environment.

The primary reason for communicating technology is, of course, to stimulate the development of better ideas and products. In addition, the waste of duplication is prevented. There is a distressing tendency apparent throughout large segments of industry to invent the wheel every day in the week. No matter how clever an invention may be, and no matter how useful its purpose, it is worthless if someone else has already invented substantially the same thing. This problem can be avoided by improving the communication of technology not only between functions in a business and between components of a large company, but also by companies and laboratories, and between eras, or periods of time.

But how should a manager of engineering determine the

optimum amount of effort to be spent by his section in "communicating" as compared with that spent in "doing?" Obviously, if all his engineers spend all their time interchanging technology, no developments or designs will be forthcoming. The right answer, of course, will vary from business to business, and from time to time. But a reasonable basis on which a specific answer might be derived for a given situation could be stated as follows: The amount of effort spent in writing, reading, attending meetings, and all the other devices for interchanging technology should be at least equal in value to the cost of engineering time lost through duplication plus the cost of preventable product failures and complaints, and the other losses which might be prevented by better interchange. The latter quantity is admittedly a little hard to measure, but attempts at estimating it might prove to be illuminating.

STAFFING

THE LAST OBLIGATION to be discussed is the staffing of the organizations. Trained manpower is a prerequisite for meeting product engineering management's obligation to staff its engineering components, and trained manpower is in very short supply. The details of this situation, including the possible causes and the potential remedies, are readily available in the literature on the subject, so only two points will be stressed here. The first point is the suggestion mentioned, that in meeting an obligation to organize to accomplish technical work, positions should be created which continuously challenge, but do not exceed, the capabilities of competent available people. Analyzing this suggestion into its two components brings us first to continuous challenge, and this is an area where we have often been seriously at fault. With the present and predicted shortages of trained people, we shall fail in our obligations if we have a highly trained person spending any regular or appreciable part of time on work which is repetitive and nonchallenging to his training and talent. There are ways to handle this predicament. Computing machines may be used to carry heavy loads of analytical work which, although exceedingly complex, may be more laborious than creative. The concept of the technican and engineering-aide positions also offers relief; this concept involves pruning the highly trained person's position of elements which can be bundled together to create a position for persons of limited technical training, to whom the work will be a satisfying challenge.

The other half of the suggestion about creating positions is that they should not exceed the competence of the incumbent. In the present state of technology there already is a great deal of day-to-day technical work which is done best by people with extensive theoretical training, and the proportion is increasing steadily. This means that there is important work for people with a PhD or equivalent degree in mathematics and the physical sciences. It also means that it is no longer feasible to ask people with more general interests and training to develop specialized knowledge on the job.

The second point to be stressed about staffing is the kind of training required in the majority of new personnel. If a good job is done of technical planning, of identifying the needs for technical work and skills, of stating the critical problems, and of designing positions, it becomes more and more apparent that the man best prepared for the bulk of engineering work in industry today is the man broadly trained in fundamentals of science and mathematics and less intensively trained in the details of currently useful devices. With this broad technical training should also be integrated a feeling for the social sciences, the humanities, and the communication of ideas. A significant part of the staffing obligation as product engineering management, is to co-operate with the technical schools in making known the nature of industry's requirements and in helping to reapportion the training load between that which is best done in school and that which can be efficiently done in industry.

CONCLUSION

THE ROOT OBLIGATIONS of engineering management in any company could be listed as follows:

1. To determine the charter for its engineering work.
2. To contribute to the over-all product plan.
3. To derive the necessary technical plan, identifying the technical work and the critical problems involved.
4. To organize to attack the problems and get the work done.
5. To define relationships with other functions.
6. To exchange technical information.
7. To staff the organization.
8. To get the work done.

These obligations should be the primary concerns of engineering management as the basis for its direct contribution to the business. The ability of the business to meet its broad social and economic obligations will depend upon the manner in which these obligations are met. It should be recognized that these direct obligations are both highly dynamic, and strongly and subtly interdependent. The continuing task, therefore, is one of optimizing relationships among them, as well as optimizing product designs to incorporate the dynamics of technology and of the market place.

New Cable-Coating Materials Used

Asbestos felt and neoprene-impregnated Fiberglas cord have replaced a mixture of sand and cement for arc proofing the high-tension cables in manholes of Consolidated Edison Company's electric distribution system in New York City and vicinity. Use of these materials has resulted in considerable labor savings on the job, and less time consumed in travel and setting up equipment and material.

In the new method, an undercoating of asbestos is first applied in 10-foot lengths. An outer layer of impregnated asbestos follows and is secured by neoprene-impregnated cord. Glass cord was selected partly because it will not burn and partly because it can best withstand heat from arcing or accidental fire.

An Experimental Transistorized Calculator

G. D. BRUCE

J. C. LOGUE

The first fully operative transistorized calculator complete with automatic input and output is described. This compact "all-transistor" unit requires 95 per cent less power than a vacuum-tube unit of comparable capacity. Present operating experience indicates the important role which transistors will play in the computers of the future.

THIS TRANSISTORIZED CALCULATOR is the first completely transistorized calculator with automatic input-output. The experimental engineering model, shown in Fig. 1, contains over 2,100 transistors and is functionally identical to the International Business Machines Corporation (IBM) Type *604* electronic calculating punch, a vacuum tube machine of which over 2,000 are in use. The Type *604* serves as an excellent basis for comparing a complete machine system using tubes, to a functionally identical system using only transistors and other solid state devices. In the power supply and in all the switching circuits, each function of the model is performed without the use of any tubes.

Fig. 1. The experimental transistorized computer is composed of a high-speed punching unit (left), and the transistorized calculating unit (right). The calculating unit is uncovered to show the bank of printed wiring panels on which the transistors are mounted

SYSTEM DESCRIPTION

THE CALCULATOR has a decimal arithmetic unit and decimal storage. It operates in the 1, 2, 4, 8 binary coded decimal system, with numbers transferred in parallel by decimal digit. The machine has a 13-digit decimal accumulator which is used to add and subtract. An 8-digit multiplicand can be multiplied by a 5-digit multiplier to develop a 13-digit product, and a 12-digit dividend can be divided by an 8-digit divisor to develop a 5-digit quotient. Provision is made for 32 digits of decimal storage. These are divided into 3-digit and 5-digit groups which may be combined by "assignment" into either 6- or 8-digit units. The transfer of information and the arithmetic operations are under the control of programing circuits.

The programing circuits provide an automatic sequence of 60 program steps to control the mode of operation. The machine is instructed to perform a desired computation by wiring a pluggable control panel. Sixty program step exit hubs control sequentially the execution of arithmetic and logical functions which have been wired on the control panel. These panels can be interchanged to alter the calculations. Another control panel is used to direct the operation of the input-output unit.

The input-output is by punched cards. A card punch is used for reading and punching at 100 cards per minute. Cards are fed first to a reading station, then to a punching station, and finally past a second reading station before being stacked. A total of 37 digits plus signs can be read into the calculator, and 29 digits plus signs can be punched out. Calculations are performed at a basic pulse repetition rate of 50 kc. The computer cycle occurs between the time a card is completely read at the first reading station and before it arrives at the punching station. Thus, the calculated result is being punched in one card while the next is being read. As a service check, the calculator should operate without failures at 70 kc.

TRANSISTOR CIRCUIT DESCRIPTION

THE GERMANIUM JUNCTION TRANSISTORS used in this experimental machine are fairly low frequency response units. Some of the first transistors used had a 700-kc minimum alpha cutoff frequency, but later transistors were specified for a 1-mc alpha cutoff frequency. The grounded emitter current gain of the junction transistors was specified as 40 minimum and 90 maximum, although some of the transistors used had grounded emitter current gains as

Essentially full text of a conference paper presented at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955, and recommended for publication by the AIEE Committee on Computing Devices.

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high as 200. The reverse current at room temperature was specified as 10 microamperes maximum at 5 volts reverse bias.

Junction transistors have characteristics that make them very satisfactory for use in switching circuits. One desirable characteristic is that they approach an ideal switch. While they are more temperature sensitive than point-contact transistors, their cutoff collector current is two or three orders of magnitude smaller than that which point-contact transistors exhibit. This feature, plus their high current gain in the grounded-emitter configuration, makes them applicable to this type of machine, which uses an essentially d-c type of logic with a signal range of 5 volts. The decision to use a signal with a 5-volt excursion, from −5 volts to ground, was made for several reasons. First and most important of these was the necessity for reliability. Early experience indicated that the cutoff current of a transistor had a higher rate of increase with time at the higher collector voltages than it did at the lower collector voltages. This indicated that a low collector voltage, and hence a low signal swing should be maintained.

The use of low signal levels introduces several problems, one of these being in respect to the use of visual indicators. The *NE2* neon indicator is a rather efficient light producer but requires a voltage change of at least 20 volts for operation. This voltage is obtained with separate voltage amplifiers, hence lower signals can be used for the switching circuits. Another problem is that the signal level also influences the speed of operation and energy required in a transistor switching circuit. The alpha cutoff frequency of a transistor is directly related to the collector voltage, and the collector capacitance is inversely related to the collector voltage. Both of these factors indicate that a high signal level is best for high-speed operation. However, the larger the signal excursion, the larger is the energy stored on stray capacitance. A system with 20-volt signals has 16 times as much energy stored on the stray capacitance as is stored on the stray capacitance of a 5-volt system. In addition, the "punch-through" voltage which can limit the peak inverse voltage rating of a transistor, bears an inverse relationship to the alpha cutoff frequency. These factors indicated that future high-speed machines would of necessity operate with low signal swings. In addition, a collector supply voltage could be used which is three times the collector clamp voltage. This would achieve reasonably short recovery times without the use of excessively large supply voltages. Another benefit derived from the use of low voltages is that the power supply voltages can be applied or removed in a random sequence, and that cards can be removed without the necessity of removing power. As a result of all these considerations, it was felt that a 5-volt signal swing should be reasonably close to optimum.

Various types of basic circuits are employed to accomplish the necessary switching and control functions. Included among these circuits are inverters, emitter followers, triggers, logical circuits, and output drivers.

Inverter. The inverter is shown in Figs. 2*A* and 2*B*, using both *PNP* and *NPN* types of junction transistors. This gives the system designer an advantage not realized with vacuum tubes. The *PNP* inverter is capable of charging a capacitive load rapidly when a positive output is required. Conversely, the *NPN* inverter can be used when a capacitive load must be driven rapidly in a negative direction.

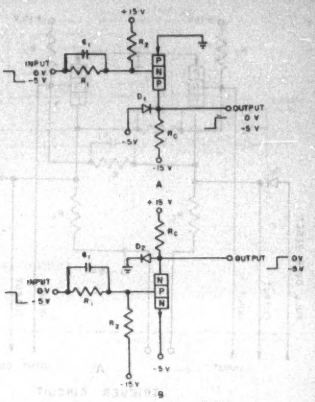

Fig. 2. Inverter

The diode clamps, D_1 and D_2, are used for two reasons. They reduce by a factor of two the turn-off time of the output signal when the inverter is driving a capacitive load. Also, the clamps firmly establish the OFF level, and make this level less dependent on the type of load being driven. Inverter circuits are particularly susceptible to minority carrier storage effects, which can cause an excessive turn-off delay. These effects can be controlled by means of resistor R_1 and capacitor C_1. Resistor R_1 is chosen so that a transistor with a minimum acceptable grounded-emitter current gain will be just held in saturation, when the input is at −4 volts for a *PNP* transistor. This means that for the same conditions, a transistor with a high grounded-emitter current gain will be driven further into saturation. The minority carrier storage delay time will be abnormally long if a large transient current is not caused to flow into the base terminal when the transistor is turned off. The capacitor C_1 causes this transient current to flow into the base when the input is returned to ground, thus supplying an adequate charge with which to turn off the transistor. It was found that a 2.5 to 1 spread in grounded-emitter current gain gave a reasonable turn-off time with a moderate

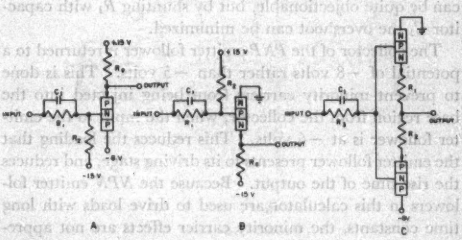

Fig. 3. Emitter follower

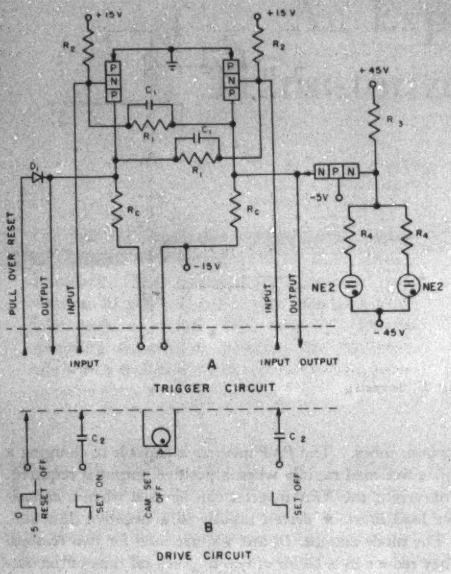

Fig. 4. Ring counter

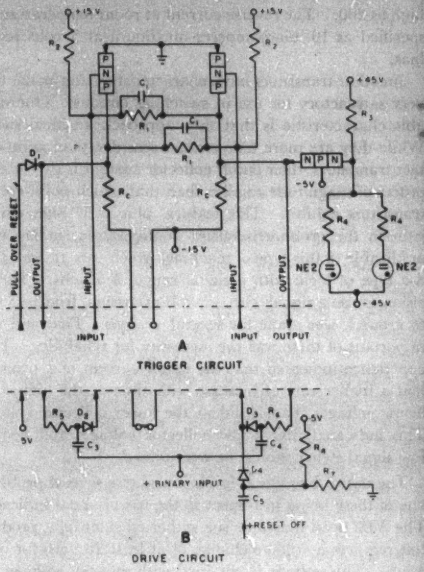

Fig. 5. Counter trigger

value of capacitance for capacitor C_1. The value of the load resistor R_e is chosen so as to limit the maximum collector current to 5 milliamperes.

Emitter Follower. The circuit for the emitter follower is shown in Figs. 3*A* and 3*B*. It is desirable, as in the case of the inverter, to use both a *PNP* and an *NPN* type of emitter follower. The characteristics of the emitter follower cause the signal to suffer a loss in amplitude and a shift in level. After the signal is lowered by several stages of emitter followers or diode logic, the loss in amplitude is corrected by passing the signal through an inverter or level resetter. The shift in level, on the other hand, is compensated for at each emitter follower. This is achieved by means of resistors R_1 and R_2, and the voltage to which R_2 is returned. One serious difficulty encountered with an emitter follower when driving a capacitive load is an overshoot in the output waveform. If the resistor R_1 is not by-passed, this overshoot can be quite objectionable, but by shunting R_1 with capacitor C_1 the overshoot can be minimized.

The collector of the *PNP* emitter follower is returned to a potential of -8 volts rather than -5 volts. This is done to prevent minority carriers from being injected into the base region from the collector, when the input to the emitter follower is at -6 volts. This reduces the loading that the emitter follower presents to its driving stage, and reduces the rise time of the output. Because the *NPN* emitter followers in this calculator are used to drive loads with long time constants, the minority carrier effects are not appreciable.

When fast rise and fall times are required with capacitive loads, a complemented emitter follower (Fig. 3*C*) is used. Positive-going input waveforms cause the *PNP* transistor to cut off and the *NPN* transistor to supply the load current. If the input waveforms are negative-going, the *NPN* transistor cuts off and the *PNP* transistor discharges the capacitive load. This circuit can drive 12 triggers in parallel at a pulse repetition of 50 kc.

Trigger. The basic (Eccles-Jordan) trigger is shown in Figs. 4*A* and 5*A*. The collectors are clamped at -5 volts by means of diode D_1 on the left side, and the emitter to base junction of the *NPN* indicator transistor on the right side. As was mentioned previously, the signal swing is too low to ignite a neon indicator and, therefore, a larger signal is developed by means of the *NPN* neon indicator transistor. The collector of this transistor can achieve a voltage excursion of 40 volts for operating the neons.

A total of five different types of triggers are used in the machine, differing only in how they are driven. Some are reset ON, while others are reset OFF. The basic drive circuits are shown in Figs. 4*B* and 5*B*. Fig. 4*B* is the type of input used when a trigger is operated in a ring circuit. The trigger can be reset by means of a cam-driven contact which opens the collector supply on one side of the trigger. It can also be reset by means of diode D_1 when the input is driven positive by a *PNP* inverter which is normally off. This input is at -5 volts until the inverter conducts and resets the trigger off. Positive-going waveforms on the SET ON or SET OFF inputs set the trigger in the ON (right transistor conducting) or OFF (left transistor conducting) state, respectively.

Fig. 5*B* shows the type of input connection that is used with counter triggers. The diode D_1 is connected to -5 volts and no cam reset is required. The purpose of R_5, D_2, C_3 and R_6, D_3, and C_4 is to act as gates or "steering" circuits. Capacitor C_5 and diode D_4 provide a reset off input. These binary triggers are cascaded, with blocking feedback from the fourth stage to the second stage, to form a binary-coded decimal counter.

Decimal Counter. The decimal counter is used for the 13-digit accumulator, a 5-digit MQ, and the 32 digits of storage, for a total of 50 decimal counter positions in the machine. The timing conditions in this counter are aggravated by the low frequency response of the early junction transistors that were used. One frequency limitation that became apparent is the delay accumulated in the "carry" from a 4-stage decimal counter. This delay was avoided by using a circuit (Fig. 6) that detects if a 9 is contained in the 1-2-4-8 counter. The tenth input pulse is gated directly through the counter to produce a "carry" with no delay due to the transition time of the triggers. This "fast carry" is accomplished by a three-way OR circuit. The inputs to the OR circuit are from the counter input and from the first (1 *TR*) and fourth (8 *TR*) stages of the counter. The output of the OR circuit can swing negatively only if the counter contains a 9 and the input is negative. When the tenth input pulse goes positive, an immediate output occurs from the OR circuit to indicate the presence of a carry.

Timing Ring. An application of the ring trigger circuit discussed previously is in a timing ring shown in Fig. 7. This ring has its alternate stages driven by two separate "advance" lines. The ring is arranged so that the "odd" stages are driven OFF on one "advance" signal and the "even" stages are driven OFF on the next successive signal. Any stage that is being driven OFF can be coupled to the next stage to turn it ON. The two advance lines are each coupled to alternate triggers by a common line driven by an inverter; these lines clamp every other stage of the ring in the OFF state. The outputs of each trigger are capacitively coupled to the corresponding bases of the transistors in the next stage. Therefore, any trigger in the ring that is pulled OFF will drive the next successive trigger ON with a fast regenerative action.

Logical Circuits. Logic is performed both with diodes and with transistors. Transistor logic is used wherever the requirements of speed dictate. The AND operation is performed by means of *PNP* emitter followers paralleled with a common load resistor as shown in Fig. 8*A*. The output is at ground if X and Y and Z are each at ground level. The OR operation is performed by the circuit shown in Fig. 8*B*, with the output at ground level if either X or Y or Z is at ground.

Output Driver. The relays and other electromagnetic devices in the calculator are driven by a power transistor developed and fabricated by IBM.[1] This transistor exhibits a negative resistance characteristic and is used in a manner very similar to the use of a thyratron tube. The relay driver circuit is shown in Fig. 9. The thyratron-like transistor will "latch on" with a short duration input pulse and the collector circuit is opened mechanically in order to return

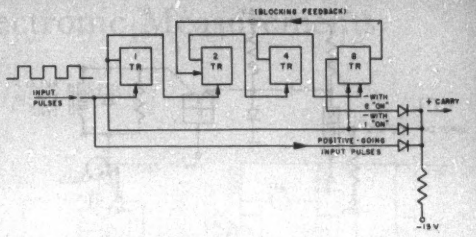

Fig. 6. Coded decimal counter

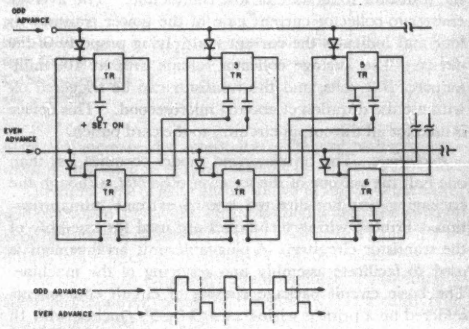

Fig. 7. Timing ring

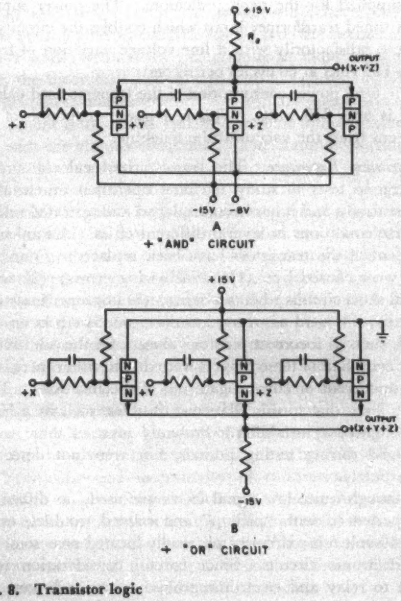

Fig. 8. Transistor logic

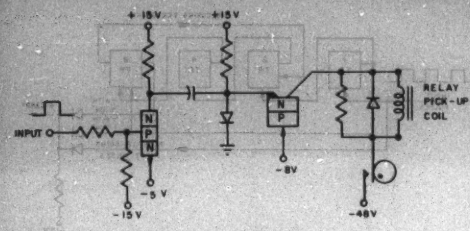

Fig. 9. Relay driver

the transistor to its state of low conduction. The average emitter-to-collector current gain of the power transistor is four and indicates the current multiplying property of the device. The average collector voltage drop at 100 milliamperes is 2 volts, and the transistor can be triggered ON with a pulse duration of about 1 microsecond. This device is used for all the output circuitry to the card punch.

Packaging. The transistorized model occupies less than one half the volume of the vacuum tube *604*, although the packaging was not directed toward extreme miniaturization. Printed wiring techniques are used for assembly of the transistor circuitry. A pluggable unit arrangement is used to facilitate assembly and servicing of the machine. The basic circuit package consists of circuit components soldered on a printed wiring card, 3 by $5\frac{1}{2}$ inches, with 18 terminals. The 595 cards in the calculator are composed of a total of 40 different types.

The supply voltages used are 15, −5, −8, and −15 volts for the transistor circuits. In addition, 45 and −45 volts are supplied for the neon indicators. The power supply has a tuned transformer input which enables the circuits to operate satisfactorily with a line voltage variation of from 90 to 125 volts at 60 cycles per second.

The total power consumption of the transistorized calculator is only 310 watts. This is a power reduction of 95 per cent from the vacuum-tube machine.

Operating Experience. The transistorized calculator has undergone tests to study machine operation at elevated temperatures and it has been displayed and operated under adverse conditions in several different cities. A total of 5 per cent of the transistors have been replaced. Four per cent were caused by: (1) initial wiring errors; (2) accidental short circuits when servicing; (3) improper insertion of cards; (4) card at wrong location; or (5) errors on the cards, such as incorrect resistor values. Of the additional 1 per cent, half of these failures were due to either increased reverse current or current gain out of specifications. The others were due to miscellaneous troubles, such as a high noise figure or instability. Probably most of these were damaged during testing periods, but were not detected immediately.

Although quite low signal levels are used, no difficulty is experienced with "pickup" and related troubles, even with 40-volt relay circuitry physically located near some of the electronic circuits. Since careful consideration was given to relay and electronic ground return isolation, no trouble results from induced voltages caused by relay dropout nor from other transient voltages.

Special precautions are not taken when transistors or printed wiring cards are removed or inserted with all voltages on the machine. Also, any voltage can be removed from the electronic circuits without damaging transistors, and the voltages can be removed or applied in any sequence.

The transistor machine can be readily serviced, and the circuitry is easily understood by engineers familiar with vacuum tube machines. It even offers a few additional servicing advantages because the lower voltages are somewhat safer and no filament warm-up time is required.

CONCLUSION

THE EXPERIMENTAL transistorized calculator contains 2,165 transistors and 3,600 germanium diodes, with no vacuum tubes. Operating experience has proved very satisfactory and indicates that the transistor will play an important part in the computers of tomorrow.

The use of transistors in future computers promises many advantages. In addition to the obvious advantages of transistors in providing size and power reduction, the most important factor is the expected long life of transistors, which should provide a much higher degree of system reliability.

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Production Flexibility Attained

A 90-ton generator rotor descends into one of three new heat treating furnaces installed at U. S. Steel's Homestead District Works, Pittsburgh, Pa., forging facilities recently expanded. A quenching tower adjacent to furnaces prevents excessive cooling of forgings in transfer.

A Novel Circuit for Electronic Measurements

ABDEL-HALIM AHMED
MEMBER AIEE

A NEW DESIGN PRINCIPLE is the basis for three novel types of electronic measuring instruments. The instruments are direct reading and may be used to measure power, power factor, voltage, or current.

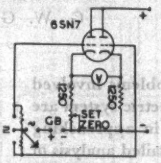
All circuits utilize essentially two tubes, operated as cathode followers, in a push-pull fashion, so that the inherent property of a wide-range linear characteristic is used with advantage. The new principle underlying the operation of the tubes involves the commutation of their currents in alternate half cycles by means of a square-wave generator, while an alternating signal is applied to their grids. The resulting average tube current is a direct measure of the product $I \cos \varphi$ or $V \cos \varphi$; I, V, and $\cos \varphi$ being respectively the current, voltage, and power factor of the circuit under measurement.

A rectifier gives a direct current proportional to the alternating voltage. For the measurement of power, an electrodynamic instrument multiplies the two direct currents which are proportional to $I \cos \varphi$ and V. For the direct reading of power factor, the quotient of the two direct currents which are proportional to $V \cos \varphi$ and V is obtained. The division is effected by means of a novel d-c division device, which is essentially a twin logarithmic-scale d-c instrument with a moving scale.

The first type of instrument, shown in Fig. 1, is the grid-controlled type. The tubes are biased to work on the midpoint of the linear part of their control-grid/plate-current characteristic. The square-wave signal is of sufficient negative amplitude to ensure that the tubes cutoff during alternate half cycles. It is obtained from a square-wave generator which gives an output of the same frequency and in phase with the a-c signal applied to its input. When this latter is derived from the voltage V, and the a-c signal applied to the commutating tubes is proportional and in phase with I, the reading of the indicating instrument is directly proportional to the product $I \cos \varphi$. The indicating instrument may be a simple d-c instrument bridged between the cathodes, or a differential instrument with one coil connected in the cathode circuit of each tube.

When the input to the square-wave generator is derived from I, the device becomes an ammeter with a linear scale, while when the a-c signal applied to the commutating tubes is derived from V, the device becomes a voltmeter with a linear scale.

The second type of instrument is the suppressor-controlled type. The square-wave signal is applied to the suppressor grids of two pentodes, while the a-c signal is applied to their control grids. The screen grids are cross-connected to the plates to increase the sensitivity. The indicating instrument is connected in the plate circuits.



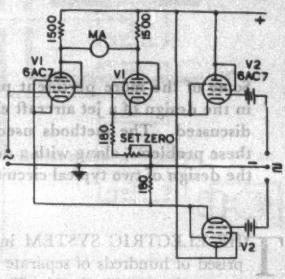


Fig. 1 (above). Grid-controlled I cos φ meter Fig. 2 (right). Cathode-controlled I cos φ meter

The third type of instrument, shown in Fig. 2, is the cathode-controlled type. When $V2$ is conducting, the voltage drop across the common cathode resistor will cause $V1$ to cutoff, while when $V2$ is cutoff, $V1$ will be conducting.

The two latter types have the advantage of providing a suitable grounding point for the circuit. The third type is suitable for use at much higher frequencies.

The different sources of error affecting the performance of the instruments are analyzed, and the resulting errors are found to be very small. The predicted higher frequency limit is of the order of 30 mc at unity power factor and 3.5 mc at zero power factor. However, it is believed that 10 mc is a reasonable practical limit. Tests on the circuits at the higher audio frequencies gave results in close agreement with the theoretical values expected.

For power measurement, an ordinary electrodynamic instrument is used, with its coils rewound to be suitable for use with the circuits concerned. The complete wattmeter circuit was tested, at power-line frequency, by comparison with an ordinary wattmeter.

The dividing twin logarithmic instrument, devised for the direct reading of power factor, involves two identical d-c log-scale instruments placed one above the other, such that their movements rotate about the same vertical axis. The pointer of one instrument carries a light scale, on which the pointer of the other instrument reads the power factor.

The novel instruments are characterized by their simplicity in theory, circuit design, operation, and adjustment. Almost any tube type can be used. The use of negative feedback and push-pull operation eliminates rectification errors, precludes the necessity of critical adjustment of the circuit, and gives increased stability, less trouble with tube replacements, and insensitivity of calibration and zero setting to supply voltage variations. Among the good features of the instruments are the uniform scale of the indicating instrument, the low insertion loss of the series resistor in the current circuit, the high accuracy, and the simplicity of adapting the instrument for multirange use.

Digest of paper 55-1, "A Novel Circuit for Electronic Power-Factor Meters and Wattmeters and a Novel Division Device," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Communication and Electronics*, May 1955, pp. 194–204.

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Design of Electric Systems in Jet Fighter Aircraft

G. W. GODFREY

Some of the more pertinent problems involved in the design of a jet aircraft electric system are discussed. The methods used in approaching these problems, along with a detailed analysis of the design of two typical circuits, are presented.

THE ELECTRIC SYSTEM in a jet fighter is comprised of hundreds of separate circuits each of which is complete within itself. The job of the electrical designer is to integrate this intricate maze of circuits so that each may be controlled by the pilot in a simple and expedient manner.

Circuitry, however, is only a portion of the problem. An equally challenging factor is the design of the installation of electric equipment and associated wiring. In performing this task, the engineer must conceive a design which will be compatible with the available space in the airplane; will insure, within practical reason, against equipment malfunctions; will permit ease of equipment maintenance after the aircraft is complete; and will keep the weight of the electric system at minimum values, in order not to exceed design limits for the over-all weight of the airplane.

Concurrent with the search for a solution to the problems described in the foregoing paragraph, the engineer must keep abreast of the latest developments in aircraft electrical design. This is mandatory since the electric system must keep pace with the advances in other phases of aircraft design such as aerodynamics, power plant, hydraulics, surface controls, electronics, etc. Thus, it is imperative that the aircraft electrical engineer tax his ingenuity and capabilities to the limit in the ceaseless drive to design aircraft of the highest quality scientifically possible.

It is obviously impossible to cover in this short presentation all of the problems involved in jet aircraft electric system design or to describe completely the electric system. This article is intended, therefore, to aid those electrical engineers not directly engaged in jet fighter aircraft electric system design in gaining a general understanding of the electric system in a jet fighter and to consider the great challenge which is offered in this field.

APPROACH

GENERALLY SPEAKING, the design of a jet aircraft electric system requires approximately 25,000 man-hours and 10,000 laboratory man-hours. Normally, the electric system must be designed within a certain time schedule in order that the design may be co-ordinated with other system designers, and the engineering may be completed in time to meet production schedules. It is thus apparent that a relatively large number of qualified and experienced electrical engineers are required to accomplish the work represented by this estimate.

After the profile or general configuration of the airplane is determined, what might be called the approach phase of the design of the electric system is initiated. A preliminary schematic diagram of the entire electric system is prepared showing the a-c and d-c bus distribution and other major systems. From this preliminary schematic, a plan of action is formulated for the design of component systems and the installation of equipment and associated wiring. In addition, an a-c and d-c load analysis is prepared which establishes the size of the d-c generator and a-c conversion components. This phase of aircraft electric system design is extremely important and it is in this phase that the engineer studies in detail the electric system power source equipment. Schematic diagrams of the a-c and d-c power distribution systems are presented in Figs. 1 and 2.

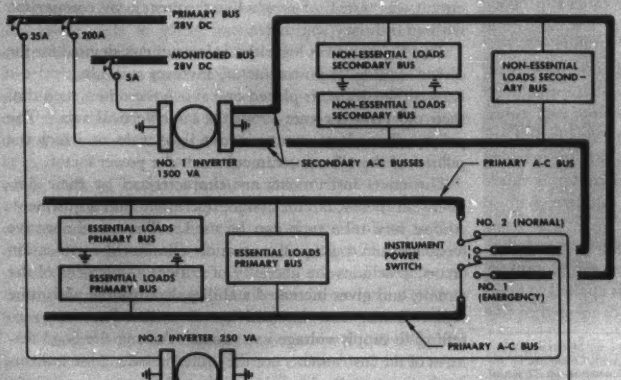

Fig. 1. Schematic diagram of a-c power busses and distribution system

Revised text of a District Paper presented at the AIEE Middle Eastern District Meeting, Columbus, Ohio, May 4-6, 1955, and recommended for publication by the AIEE Committee on Air Transportation.

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As the component circuits and equipment installations begin to take shape, they are mocked up and installed into a wooden facsimile of the actual airplane. In this portion of the approach phase, the engineer checks the preliminary electrical design against the physical limitations of the actual airplane through a three-dimensional view to make sure that the system, when completed, will conform to actual airplane requirements. Other important benefits which are realized as a result of the mockup are that the customer has the opportunity to examine the proposed electric system in the physical configuration of the actual airplane, and production personnel who are to fabricate the system can use the mockup as a training aid. For simplification, certain special circuits will be discussed.

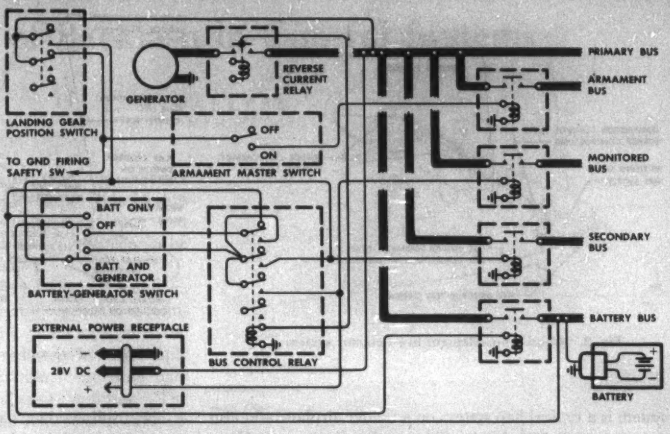

Fig. 2. Schematic diagram of d-c power busses and distribution system

FIRE DETECTORS

ONE OF THE MORE IMPORTANT auxiliary electric circuits in the airplane is the fire detector circuit. The fire detector system is considered a "safety of flight" item and, as the name implies, is a device that warns the pilot when a fire exists so that he can take immediate action to save the aircraft and, in many instances, himself.

Since fires would most likely originate in the engine compressor section or the engine burner section, these sections of the airplane are normally equipped with fire detectors. The general layout of a typical fire detector system is shown in Fig. 3. The fire detector system is normally set up with two complete circuits, one for burner and one for compressor, so that the pilot is warned as to what section of the airplane is on fire.

If a compressor fire occurs, the pilot will shut down the engine and attempt to blow the fire out before abandoning the airplane. If a burner fire exists, the pilot will reduce throttle, for the fire may merely be an overheated tail pipe.

The important installation design considerations for this system are:

1. The detector must be strategically located, so that a fire will be detected as quickly as possible after it starts.
2. The amplifiers must be located outside of a possible fire zone, since they are also used to warn the pilot when the fire is put out.
3. The wiring should be electrically and mechanically adequate. While the current carried in these circuits is relatively small, 16-gauge wire is used to assure, as far as practicable, that the wiring will not be damaged by installation and maintenance personnel.

Before the detector for a specific location can be calibrated, the ambient temperature for the area in which it is to be installed must be obtained from thermodynamics engineers. This information is necessary so that the detector alarm point can be set well above this temperature to insure against a false alarm.

After the detector installation has been designed, it is installed in a prototype airplane for flight testing. Based on the data obtained from the flight test, the system is adjusted so that it will function properly under all flight conditions.

There are several types of fire-detector systems used today. Basically, however, they fall into three categories:

1. *Rate of Temperature Rise.* This type of fire detector consists of 15 or 20 thermocouple fire detectors connected in a series and routed into an amplifier box. When the temperature around any one of these thermocouples rises fast enough, such as when exposed to a fire, an emf is generated which will close a sensitive relay, thus energizing a light in the cockpit which shows the location of the fire to the pilot.
2. *Thermal Detector.* This type of detector is, as the name implies, a calibrated thermal switch. A number of these detectors are wired in parallel and through a warning light in the cockpit. When the temperature around any one of the detectors rises above the calibrated setting of the detector, the detector or thermal switch closes, thereby illuminating the fire warning light in the cockpit.
3. *Continuous Element.* This type of fire detector device is more complex than the ones described in 1 and 2. The fire detection sensing element of this type detector consists of several, usually 10-foot long, elements located throughout the airplane in potential fire zones. These elements are connected together with 750-F fire-zone wire that will not be destroyed in a flame. The control unit is comprised of a simple resistance bridge circuit that is normally balanced, with the sensing elements as one leg of the bridge.

AIRCRAFT LIFT-DEVICES CIRCUIT

A SECOND ELECTRIC SYSTEM of interest to the aircraft electrical engineer is the aircraft lift-devices circuit. This

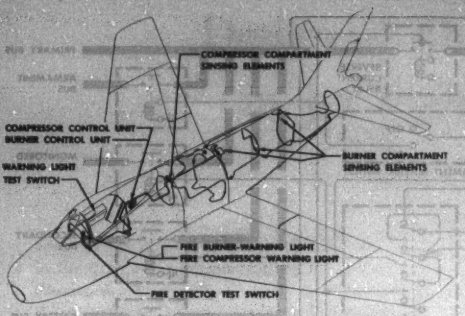

Fig. 3. Continuous-element fire-detector system

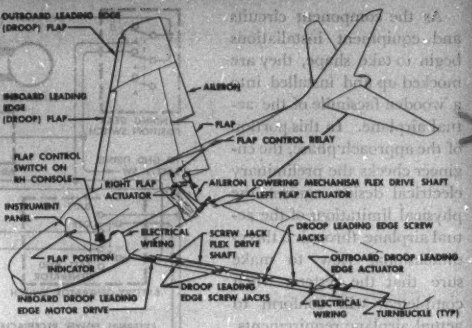

Fig. 4. Flap and droop leading-edge control system

system is a typical flap system on a fighter airplane and also a "safety of flight" circuit. The modern high speed Navy jet fighter must land at the lowest possible speed in order to be taken aboard an aircraft carrier. If the flap system were to fail, it would be hazardous to land the aircraft.

In the design of the lift-devices control circuit, the electrical designer learns from the aerodynamics engineer the forces which must be overcome when the device is lowered into the air stream and retracted into its normal position. The structural configuration of the various components to be actuated will be obtained from the wing engineers.

Creating a hypothetical problem for discussion, suppose there are ten surfaces to be lowered and raised simultaneously as shown in Fig. 4. Six of the surfaces, defined as wing leading edge flaps, are actuated by electric motor-driven actuators. It can be determined at the outset that both inboard wing flaps can be operated by one actuator. One flap will be driven by the actuator while the other is operated by a flexible shaft through a small gear box. It is not generally practical to operate the outboard flap by means of a flexible shaft off the inboard actuator, inasmuch as it must cross the wing fold. Therefore, the outboard flaps should have separate actuators, the six leading edge flaps being operated by four electric motor-driven actuators.

Sometimes the ailerons also are used as flaps. The ailerons are lowered a predetermined number of degrees during landing and take-off. Since the ailerons may be normally operated hydraulically, the action of lowering and raising the ailerons as flaps can be accomplished by a flexible shaft operated by the trailing edge flap actuators. However, a problem is brought forth by this design. That is, when the airplane is on the ground, the trailing edge flaps could be actuated inadvertently without hydraulic pressure available to the aileron. If this should happen, the flexible shaft driven by the flaps which is used to lower the ailerons would break, since the aileron could not move. This restriction can be overcome by placing a pressure-sensing switch in the hydraulic line to the aileron. This switch can be placed in the circuit so that electric power will not reach the trailing-edge flap actuator motors unless hydraulic pressure is available to the ailerons.

The trailing-edge flaps use two electric motor-driven actuators, one for each flap, although the right- and left-hand flaps are connected by a flexible shaft which is geared to both actuators. Either actuator is designed so that it alone will be sufficient to drive both flaps, in the event of failure of one. However, since it is desirable to raise the flaps as soon as possible after take-off, the power by both actuators is normally utilized. Thus, the desired characteristics are obtained, and at the same time, realistic reliability is designed into the system with the least weight penalty.

With the circuit tentatively established, the specific components must now be designed; that is, the design specification for the components must be formulated.

Simultaneously while designing and testing the components and circuits, the engineer must design the installation into the airplane. This usually is as interesting as designing the circuit. Factors that must be taken into consideration are: (1) location of flap switch and indicators in the cockpit; (2) location of actuators, relays, and pressure switches; and (3) wire routing to insure the shortest possible length and to reduce the possibility of short circuits.

It usually takes considerable design layout time in order to co-ordinate the design of the installation with all other systems going into the airplane.

SUMMARY

The foregoing examples are problems that take a major share of aircraft electric system design time and represent the type of work in which the majority of electric system designers are engaged. In summarizing, it is hoped that the information presented may be helpful in gaining a better understanding of the various basic points which must be considered in the design of a jet-fighter electric system, and that the challenge existing in this field has been made apparent. The problems facing the jet-aircraft electrical engineer run the gauntlet from the design of a simple clamp installation to the complexities which arise in the preparation of the entire system. Working hours are long and responsibilities are heavy, but jet-fighter electrical design is one of the most interesting and rewarding fields that an electrical engineer may enter.

Analysis of Backlash in Control Systems

L. M. VALLESE
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NONLINEARITIES of backlash type are characterized by a multivalued input-output relationship which depends both upon the instantaneous value and the rate of change of the input and, in general, cannot be expressed in simple analytical form.

The usual method of attack of such problems is based on the assumption that the input quantity varies monotonically between two equal and opposite peak values; then the input-output relationship assumes well-defined and simple expression and graphical representation, depending only upon the magnitude of the peak value of the input. The actual solution can be obtained with step-by-step analysis[1] and is exact, subject to the limitation implied with the assumed backlash characteristic. An approximate solution can also be obtained, assuming it has the form $x = A_x \sin \Omega t$ and applying the principle of harmonic balance.[2,3]

By application of the Kryloff–Bogoliuboff method,[4] it is possible to develop in the time instead of in the frequency domain the sinusoidal analysis of a feedback control system with 1 degree of freedom. This procedure, in addition, permits one to take into account up to a certain extent the harmonic content of the input variable in the evaluation of the multivalued characteristic.

An application is shown for an autonomous feedback system with backlash in the feedback branch of the loop, whose behavior is described by the differential equation

$$\ddot{x} + a_1 \dot{x} + a_0 y(x) = 0 \qquad (1)$$

where $y(x)$, the backlash characteristic, is a sum of a single-valued and a multivalued term: $y = Kx + f(x)$. For the backlash characteristic of Fig. 1, with $x = A_x \sin\psi$, then

$$\begin{aligned} f(x) &= -kx_0 \text{ for } -\psi_1 \leq \psi \leq \pi/2 \\ &= k(A_x - x_0 - x), \text{ for } \pi/2 \leq \psi \leq \pi - \psi_1 \\ &= Kx_0, \text{ for } \pi - \psi_1 \leq \psi \leq 3\pi/2 \\ &= -K(A_x - x_0 + x), \text{ for } 3\pi/2 \leq \psi \leq 2\pi - \psi_1 \end{aligned}$$

where $\sin\psi_1 = 1 - 2x_0/A_x$. $f(x)$ is periodic and single valued in ψ, with a Fourier spectrum of odd harmonics only

$$f(\psi) = \sum_{n=1,3\ldots}^{\infty} [f_n(Ax_x) \cos n\psi + g_n(A_x) \sin n\psi]$$

A relative measure of multivaluedness is expressed by means of the integral $\int_{-A_x}^{A_x} \frac{f(x)}{K_x}\, dx$, which becomes smaller as A_x/x_0 increases. The results of the time-domain analysis are

$$\begin{aligned} A_x/x_0 &= \frac{2\rho}{\pi\Omega^1}\left(1 \pm \sqrt{1 - \frac{\pi\Omega^1}{\rho}}\right) \\ \Omega^1 &= \sqrt{\rho}\left(\frac{3}{4} + \frac{2\psi_1 + \sin 2\psi_1}{4\pi}\right) \end{aligned} \qquad (2)$$

Digest of paper 55-15, "Analysis of Backlash in Feedback Control Systems With One Degree of Freedom," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, March 1955, pp. 1–4.

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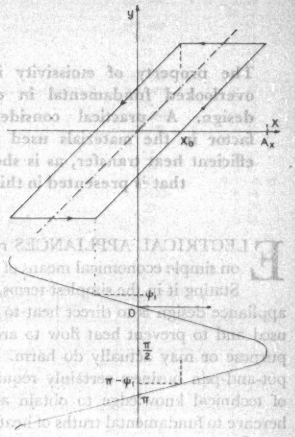

Fig. 1. Backlash characteristic for $A_x < 2x_0$

where $\rho = Ka_0/a^2$ and $\Omega^1 = \Omega/a_1$. It is found that $\pi\Omega^1 \gtrless \rho$ and that A_x/x_0 is determined uniquely in terms of the parameter $\xi = \rho/\Omega^1$. Two oscillations are obtained for each value of ρ, one unstable with amplitude A_x less than $1.6x_0$ and the other one stable with larger amplitude. Actually from step-by-step analysis it has been shown[1] that the unstable solution does not exist and the critical value of ρ for limit existence of oscillations is $\rho \cong 3.046$. The failure of the Kryloff–Bogoliuboff analysis for small values of A_x/x_0 is due to the large value assumed correspondingly by the relative measure of multivaluedness.

The method of Kryloff–Bogoliuboff provides a refinement of the solution of first approximation with the expression

$$x = A_x \sin\psi + \sum_{3,5\ldots} \frac{1}{(n^2-1)\Omega^2}[f_n(A_x) \cos n\psi + g_n(A_x) \sin n\psi] \qquad (3)$$

where f_n, g_n, have been defined previously. Using equation 3, one can re-evaluate the backlash characteristic, obtaining a new expression of type $y = Kx + F^*(x)$. Substitution of $x = A_x' \sin\psi + \sum_{3,5\ldots} B_n \cos n\psi + C_n \sin n\psi$ and application of the principle of harmonic balance finally provides a solution of higher approximation for $x = x(t)$.

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Surface Emissivity as a Factor in Appliance Design

A. D. SMITH

The property of emissivity is sometimes an overlooked fundamental in electric-appliance design. A practical consideration of this factor in the materials used is important for efficient heat transfer, as is shown by the data that is presented in this article.

ELECTRICAL APPLIANCES rely, for the most part, on simple economical means of effecting heat transfer. Stating it in the simplest terms, the object of heating-appliance design is to direct heat to areas where it will be used and to prevent heat flow to areas where it serves no purpose or may actually do harm. Electrification of the pot-and-pan business certainly requires no great measure of technical knowledge to obtain adequate results. Adherence to fundamental truths of heat transfer should be the rule, however, in designing for ultimate performance. A frequently overlooked and often misunderstood fundamental in heat transfer is the property of emissivity.

A roaster oven presents one striking example of the effect emissivity can have on the efficiency of a design. As is commonly known, a roaster consists simply of a heated outer pan containing another pan in which baking is accomplished. It might seem that any reasonable selection of materials for its construction would be suitable—since aluminum is popular for cooking utensils, inquiries are frequently received asking why the roaster pan cannot be made of this material. Also, it is often suggested that a cover given the new look by copper anodizing or, perhaps, by a colorful porcelain-enameled finish would appeal.

Although these are good ideas, they are not practical, solely because of this elusive property of emissivity. High emissivity implies good heat absorption; low emissivity is synonymous with good reflecting properties. Porcelain, being both a good emitter and good absorber, is obviously an ideal choice of finish to effect efficient heat transfer between the pans. Aluminum, being a good reflector, is a particularly suitable material for the cover, since it must reflect heat within the cooking chamber back onto the foods being prepared. One of the earliest roasters in the history of appliance manufacture employed an aluminum pan and a porcelain cover. Evidence presented in Table I shows that such a disregard of fundamentals resulted in inefficient operation. Note that this early design requires almost double the wattage needed to maintain temperatures in the modern efficient design.

A knowledge of emissivity is particularly useful when working out thermal design problems on handmade models. Since emissivity is a surface characteristic, it is necessary only to vary finishes of the components to obtain the desired results. In this manner, it is often possible to arrive at the final design using a minimum of expensive models.

DEFINITION

BY DEFINITION, the emissivity of a surface is the ratio of the intensity of radiation emitted by that surface to that radiated by a maximum emitter. It is numerically equal also to the absorptivity of that surface. For example, white asbestos board has an emissivity of 94 per cent in the infrared spectrum. It will emit 94 per cent of the radiation given out by a perfect emitter operating at the same temperature. Also, it will absorb the same percentage of radiation arriving at its surface from a source operating in the infrared zone. Reflectance is, as the word implies, the percentage of arriving radiation that a surface will reflect, being 6 per cent in the case of the asbestos board.

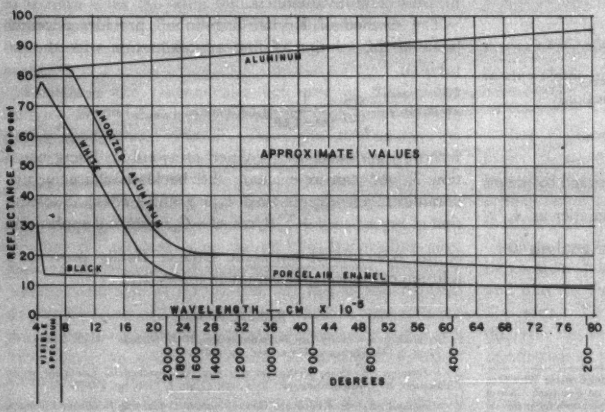

Fig. 1. Reflectance values over the effective spectrum

Full text of a conference paper presented at the AIEE Domestic Appliance Conference, Cleveland, Ohio, May 23-25, 1955, and recommended for publication by the Committee on Domestic and Commercial Appliances.

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Table I. Roaster-Oven Efficiency

Cover	Inset (Cooking Vessel)	Watts to Maintain 400 F
Aluminum	Porcelain enamel	592
Aluminum and "look-in" glass	Porcelain enamel	642
Aluminum	Aluminum	822
Porcelain enamel	Porcelain enamel	884
Porcelain enamel	Aluminum	1,170

Table II. Reflectivity of Various Lacquers on Aluminum Foil*

Description of Samples	Thickness of Coating, Inches × 10^{-4}	Reflectivity for Light, Per Cent	Reflectivity for Infrared, Per Cent
Lacquer, clear	20	80	57
	43	82	33
Lacquer with black pigment	30	5	30
	68	5	8
Lacquer with white pigment	40	67	31
	93	76	12
Lacquer with yellow dye	20	76	43
	50	68	21
Lacquer with blue dye	30	8	45
	64	5	22
Lacquer with red dye	27	28	39
	63	23	26

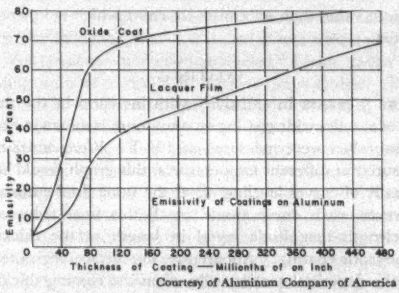
* Courtesy of Aluminum Company of America.

Table III. Sandwich Grill–Waffle Baker Improvements

	Old (Plain Aluminum Grids, Double Bottom Cover)	New (Treated Grids, Single Bottom Cover)
Wattage	1,000	800
Calibration, degrees F	520	475
Table-top temperature, degrees F	186	120
Wire-connection temperature, degrees F	795	414
Waffle time, minutes	7	4½
Preheat time, minutes	6¼	3¼

Table IV. Radiation Emissivity of Various Materials

Material	Temperature, Degrees C	Emissivity
Aluminum, polished	20	0.04
Aluminum, polished	600	0.06
Aluminum, anodized, 20 minutes	100	0.77
Aluminum, anodized, 30 minutes	100	0.86
Brass, clean	20–300	0.03
Brass, oxidized	200–600	0.60
Copper, polished	20	0.03
Copper, oxidized	200–600	0.57
Gold	225	0.02
Cast iron, newly turned	25	0.43
Steel sheet, rough or shiny, oxidized	25	0.81
Stainless steel, 18 & 8 & 8	200–500	0.40
Stainless steel, 18 & 8 & 8, heated 24 hours at 980 F	200–500	0.67
Chromium	500	0.25
Asbestos, board	25–400	0.94
Porcelain enamel, any color	20–100	0.90
Dead-white enamel varnish	25	0.90
Black lacquer, shiny	25	0.87
Black lacquer, flat	60	0.97
Various aluminum paints	100	0.23–0.78
Water	0–100	0.96
Oil on polished surface, 0.001-inch thick	20	0.27
Oil on polished surface, 0.002-inch thick	20	0.46



Courtesy of Aluminum Company of America

Fig. 2. Effect of an oxide coat and a lacquer film on emissivity

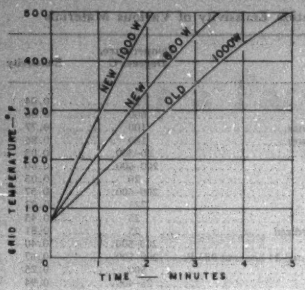
Two scientists, Stefan and Boltzmann, working independently, did the initial research on emissivity characteristics and undoubtedly contributed greatly to a better understanding of heat transfer. Unfortunately, their terminology in describing a perfect emitter as a black body has led to many popular misconceptions. A surface approaching black-body emission is white hot at 1,500 C, red when medium hot, and may be any color for the invisible long wavelengths of heat encountered in the majority of electrical appliances. The fact is that a black body is black only in the narrow visible spectrum. While the eye can appraise and judge a surface's emissivity in this narrow band it cannot be relied upon to evaluate characteristics in the much broader infrared range. A notable example which belies the eye's judgment is hoar frost, which is visibly white and a good spectral reflector, but will absorb 98.6 per cent of all incoming radiation in the infrared range for one of the highest emissivities known.

REFLECTANCE VALUES

ALL MATERIALS are selective emitters or absorbers to some extent and have varying characteristics over the spectrum from visible to infrared wavelengths. Fig. 1 shows reflectance values for a few materials over this complete spectrum. Actually, a third variable, imagination, is included in this graph since curves are merely joined over a large span of wavelengths where reflectance values are not available. The curve for white porcelain enamel shows a reflectance averaging 75 per cent, as recorded in the visible spectrum by a spectrophotometer. Notice, however, that reflectance falls off sharply in the infrared spectrum until it reaches a value of only 9 per cent at peak wavelengths corresponding to 200 F. That color has no effect on long-wavelength reflectance is shown by the coinciding curves for white and black porcelain enamel at values beyond the visible spectrum.

Contrast also the relative reflectances of untreated and anodized aluminum, as shown in Fig. 1. Like most metals, aluminum has the lowest reflectance for ultraviolet, and has increasing values for increasing wavelengths. While the anodized-aluminum surface may actually gain light reflectance by electrolytic brightening, its reflectance falls off to 14 per cent at peak wavelengths at 200 F.

Emissivity must be measured at temperatures below which a material will change state by combustion or melt-



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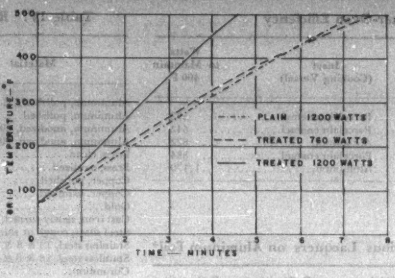

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Fig. 3. Sandwich grill-waffle baker heating times before and after emissive cement coating to underside of grids is added. Fig. 4. Sandwich grill-waffle baker heating times before and after bimetal of thermostat is coated with high-emissive paint, and a baffle added

ing. The surface of a material will react to wavelengths from a source having higher temperatures than it would be possible to obtain on the material being investigated. For this reason, a reflectance chart such as Fig. 1 is perhaps of more value than an emissivity chart which is inherently limited.

COATINGS

The increase in emissivity with increases in the thickness of anodic-oxide coating on aluminum is shown in Fig. 2. These values were measured at 100 F. Were emissivities measured at different temperatures, this graph would show a family of curves leveling off at the same final emissivity. However, each curve would reach this final value at a wavelength magnitude equal in length to the thickness of the oxide coating. Apparently, the surface begins to act like the deposited coating only when the coating thickness is of the same magnitude as the emitted wavelength. Fig. 2 and Table II show the effect of various lacquer coatings on aluminum, and point out the fact that color has little effect on emissivity at 100 F. It is the chemical nature and physical state of the surface that determines its emissivity, not its color.

The rather peculiar effect that anodic coatings have on the emissivity of aluminum affords the designer an opportunity to choose a visually bright surface and, at the same time, to select a surface of either high emissivity or reflectance at ordinary operating temperatures. During the development stages in the design of a rotisserie it was found that motor-coil temperatures were marginal, and slightly exceeded limits set by Underwriters' Laboratories. The motor had been isolated from direct contact with metallic components, and a practical maximum of ventilation had been provided. All types of motor-mounting insulations were tried in addition to many "last resort" schemes for redirecting the flow of air over the motor. A decorative aluminum escutcheon had been provided with ventilation slots and was placed adjacent to the motor. Although this escutcheon was providing adequate ventilation, it was, at the same time, reflecting heat within the motor chamber directly back onto the coil of the motor. Anodic treatment of the escutcheon destroyed its high reflectance, served to pick up heat radiated by the motor, and dropped the coil temperature to a point where a good safety factor existed. This simple expedient had been overlooked until the last stages of design, as ventilation and insulation had seemed to be the most obvious solutions to the problem. Anodizing, of course, can be detrimental, as in the case of a roaster cover given the new look by anodizing and dyeing a copper color. The oxide coat thus formed increased the cover's emissivity to such a degree that radiant heat losses prevented adequate browning of foods and increased the watts necessary to maintain temperatures.

REDESIGN

Until recently, it was common practice to attempt to heat aluminum sandwich-grill or waffle grids by direct radiation from an open-coil heater. Often the reflector directly under the coils had a protective nickle plating. The inefficiency of such design is obvious, as the aluminum grids reflected better than 90 per cent of the radiant heat back onto the nickel-plated reflector which soon oxidized and absorbed a high percentage of all radiations. The net result was a rather efficient heating of the table upon which the appliance rested, as well as the components other than the grids.

Data of Table III and curves of Fig. 3 show the improvement realized in the redesign of a sandwich grill–waffle baker combination by adding a highly emissive cement coating to the underside of the grids. Heating of the grids was accelerated even with reduced wattage; high temperatures at troublesome points were minimized; also an expensive double-bottom cover was eliminated. Such redesign was not accomplished, however, without considerable work in developing a thermostat that would respond to the rapid heating of the grids. Conventional thermostats lagged grid temperatures and failed to cut off at the proper time, resulting in excessive overtravel. Emissivity again provided the key to this problem. The bimetal of the thermostat was coated with a high-emissivity paint, and a baffle with the same treatment was placed next to the bimetal to prevent its receiving direct radiation from the coils. Reradiation from the grids was picked up by the coated bimetal and baffle, adding to the response provided by conduction and resulting in a sensitive thermostat. Fig. 4 shows another heating curve for such a combination appliance, utilizing coated grids and a similar thermostat. Aluminum-coated steel serves as both a heater support

and reflector in this design. Although the thermostat for this appliance is in contact with the grids, it will operate satisfactorily when responding only to heat reradiated from the grids. Such results could not be obtained were ambient temperatures surrounding the thermostat at substantially higher levels than the grid temperature. Thermocouples placed to measure ambient temperature show that it follows grid temperatures closely. Efficient transfer of radiant heat has this effect of keeping ambient temperatures low, and can contribute to a large extent in keeping components such as handles and bottom covers cool.

SELECTIVE COATING

THERMAL DISTRIBUTION can be controlled very effectively by selectively coating surfaces with preparations having the desired emissivity. Fig. 5 shows a broiler–griddle attachment for a roaster that employs the principle of selective coating. A coil conformation designed to yield a good heat pattern for broiling tended to make the center of the cooking platform hotter than the edges when the unit was used as a grill. Bottom edges of the platform were coated with a high-emissivity cement, adding heat to the borders and evening out the heat distribution. Note that the highly absorbing cement surface is shielded by an aluminum reflector when the appliance is used as a broiler.

Selective coating is used also to obtain good thermal distribution in a sandwich grill–waffle iron combination. Even heat distribution could be obtained on either set of grids independently, but coil conformations suitable for one set did not provide an even heat pattern for the other set as they differed in mass. The lighter set of grids was selectively coated to obtain the desired heat pattern. This particular appliance was merely a redesign intended to improve efficiency by the use of high-emissivity coatings. Retooling of any major components was avoided by the simple expedient of selective coating.

HEAT SHIELDING

TABLE-TOP TEMPERATURES have always been a problem in designing electric housewares. This was particularly true in the days of the nonautomatic appliance. In one early nonautomatic sandwich grill, a bottom cover fabricated in nickel-plated steel was used as a heat shield. Table temperatures rose at a moderate rate until the nickel plating became oxidized. The increase in emissivity resulting from oxidation soon caused table temperatures to rise rapidly to a point where a definite fire hazard existed. An aluminum bottom cover solved the thermal problems, but failed to provide the structural strength necessary since the bottom cover served as a retaining member for securing the grids and supporting the feet. Aluminum-clad steel was just being offered on the market at the time of this development. The use of this material for the bottom-cover application solved both the thermal and structural problems and provided a part that retained its good reflectance over the life of the appliance. Since that time aluminum-coated steel has been employed successfully where strength and low emissivity are required. It is a relatively inexpensive material and is particularly suitable for heating element supports and reflectors under open heaters. Significant lowering of all component temperatures was realized when this material was used to replace the conventional porcelain-enameled shields under the heating units of a "built-in" surface-range design. Effective heat shielding is a necessity in "built-in" design. Here, control of emissivities can be an all-important factor.

It has sometimes been assumed that since a material is a good insulator for conducted heat, it must, as a consequence, be a good insulator for radiant heat. Asbestos has sometimes been misused for thermal insulation where only radiant-heat losses exist. An example of this is the practice of wrapping galvanized hot air ducts with $^1/_{32}$-inch-thick asbestos paper. The thin paper does little to reduce the exposed temperature of the pipe while increasing its emissivity from 25 per cent for galvanized sheet to 94 per cent for the asbestos paper. It is evident that increased heat losses could be expected from an application of this type. An investigation into the use of asbestos for insulating a nickel-plated bottom cover on a hot plate showed an increase in table-top temperatures under the cover of 50 F.

Fig. 5. Selective coating is added to broiler-griddle on left

Fig. 6. High-emissivity paint is added to toaster thermostat

Aluminum foil, of course, would be the material to use in such an application. Inexpensive aluminum foil can be placed strategically in many instances to baffle radiant heat. It is also useful for eliminating "hot spot" problems. A radiant heat shield of this material placed behind the thermoplastic skirt of a fat-fryer knob prevented the part from reaching distortion temperatures and also conducted heat away from a "hot spot," resulting in a fairly even heat distribution over a material particularly sensitive to temperature gradients.

THERMOSTAT

A SENSITIVE THERMOSTAT in one toaster application is designed to cycle the main heaters which, in effect, meters the amount of radiant heat reaching the bread. This thermostat, shown in Fig. 6, must sense and correct for changes in ambient temperatures caused by successive toastings and changes in line voltage. A high-emissivity black paint is used to make the bimetal immediately responsive to such changes. That an emissive coating is ideal for such response to received radiations is obvious; a less obvious advantage is that the coating allows the thermostat to rid itself of stored heat by radiation and to ready itself for the next toasting cycle after one operation is complete. Emissive coatings can be very effective where the mass of a thermostat causes an initial heat lag in the bimetal and subsequent heat storage in the thermostat assembly causes it to cool more slowly than the areas to be controlled.

Often it is advantageous to "fix" the emissivity of the active members of a thermostat. Surface oxidation in addition to dirt film deposits on the surface of a bimetal may raise its emissivity and interfere with the intended operation. Such a condition was found to result from normal field service of a dryer safety thermostat. This thermostat was operating prematurely after a period of usage because of increases in emissivity due to operation in a heated moist atmosphere. Emissivities of the disc-type bimetals returned from the field were found to be considerably higher than installed values. Factory application of a coating whose emissivity exceeded that of the field samples was found to be a satisfactory solution. In this manner, an emissivity was provided that would not change in field service. Aluminum paint being quite impervious to atmospheric conditions was also found to be a satisfactory coating for this bimetal.

FINISHES

HEAT-SELECTIVE FINISHES provide the designer with an opportunity to use whatever base material lends itself best to fabrication and at the same time to select a reflecting or absorbing surface. The use of such finishes may also add to the economy of a design, as an inexpensive base material can be used, and painting costs are inherently low. Good heat reflectance is characteristic of the aluminum-pigmented paints, particularly of the epon varnish and silicone types, which will withstand temperatures exceeding 500 F. The per cent and type of both the aluminum pigment and the varnish resin determine the degree of reflectance of a finish. As a general rule, the flaky aluminum pigments combined with a low solid content vehicle provide the best reflecting surfaces. Emissivities vary from 75 per cent for a paint using finely ground pigment and a high solids vehicle to 25 per cent for a good leafing flaky pigment in a thin vehicle.

Where efficient absorption or radiation of heat is desired, a number of finishes are very effective. The recent introduction of silicone resins provides the industry with a vehicle that may be combined with various fillers to provide for high emissivity at elevated temperatures. Mica powder added to a modified silicone varnish yields the highest emissivity of any finish tested over a period of 7 years. Leafing of the mica appears to add to the paint's emissivity and also extends the life of the finish at high temperatures. Other excellent absorbing coatings are available in the inorganic high-temperature cements. Many of these cements will withstand temperatures higher than any occurring in the severest appliance application. A black pigment such as lamp or bone black may be added to these usually light-colored compounds to give an appearance which customers will associate with good heat absorption. The psychological effect of black coloring should not be overlooked even though its addition contributes nothing to the emissivity of the coating. Various graphite colloidal dispersions may be used also for absorbing finishes. Such finishes will withstand abrasion and severe bending of the base material.

Emissivities of various materials are tabulated in Table IV. Note particularly the increase in emissivity caused by coatings of oil on the surface of steel. The best reflectors may be adversely affected by oily surface deposits. A sandwich grill that had performed well over an extensive period of manufacture suddenly failed to pass table-top temperature tests. After much over analysis of a simple problem, it was found that an economy minded foreman had eliminated a cleaning operation on the bottom cover after the part was fabricated on presses. A thin layer of oil deposited from the punch presses was again removed and the difficulty disappeared. Condensation of moisture on a surface will increase its emissivity to a value over 90 per cent and can cause considerable difficulty also. While yielding a visibly shiny film, water with its emissivity of 96 per cent is one of the best absorbers known.

CONCLUSIONS

THE FOREGOING EXAMPLES are intended to point up the importance of emissivity in design considerations. It should not be construed, however, that this is a magical property that will provide a solution for all of the problems encountered in appliance design. In the final analysis, a delicate balancing of conduction, convection, and radiation is necessary to efficient design. Emissivity does provide a fertile field from which many design variations can be attained. Proper attention to emissivity in the development of most appliance designs can result in increased efficiency, better thermal distribution, and improved performance.

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Voltage Dip Caused by Arc-Furnace Loads

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FELLOW AIEE

A STUDY WAS MADE recently to determine the magnitude of the angular swing produced in a synchronous condenser by sudden application of an arc-furnace load, and the effect of this swing on the magnitude of the voltage dip.

In some arc-furnace installations, objectionable voltage dips have been reduced by use of a buffer-reactor and synchronous-condenser combination. The synchronous condenser reduces the magnitude of the voltage dip, as caused for example by a secondary short circuit, by providing a parallel impedance path so that a substantial part of the current is drawn from the synchronous condenser rather than from the system. To make the condenser more effective and economical, a buffer reactance is inserted often between the arc-furnace transformer bus and the system. This causes the system to take an even smaller share of the current. To reduce the reactance of the synchronous condenser, a capacitor has been inserted sometimes in series with the condenser. In some cases when series capacitors have been used, trouble has been experienced because of the gap across the capacitor arcing over on secondary short circuits just when the capacitor is needed to reduce the consequent voltage dip. This capacitor arc-over usually has been explainable on the basis of the normal transient voltage resulting from the short circuit. However, several questions which bring in the possibility of condenser swinging have been brought up in connection with some of these cases:

First, in a particular application, will the condenser swing increase the voltage dip?

Second, there has existed the fear of possible condenser instability if the buffer reactance is increased too much.

Third, it has been suggested that the transient series-capacitor voltage might itself be aggravated by condenser swings.

Fourth, it has been suggested that some of the disturbances observed might have been caused by the condenser temporarily going out of step.

In order to throw some light on these questions, a simple system was set up on the General Electric Company's differential analyzer and disturbed by application of secondary short circuits. Resistance had to be included in the short circuit in order to produce any condenser torque, and thus any condenser swing. This secondary-fault resistance was varied over a wide range in order to produce the maximum swing. Two conditions of condenser excitation were considered: the condenser was assumed to be operating initially with normal no-load field excitation, and then initially with zero field excitation (with unit terminal voltage in both cases) for each short-circuit applied. A condenser voltage regulator was assumed to be in operation in most cases. Two examples showing the condenser terminal voltage and rotor angle are shown in Fig. 1.

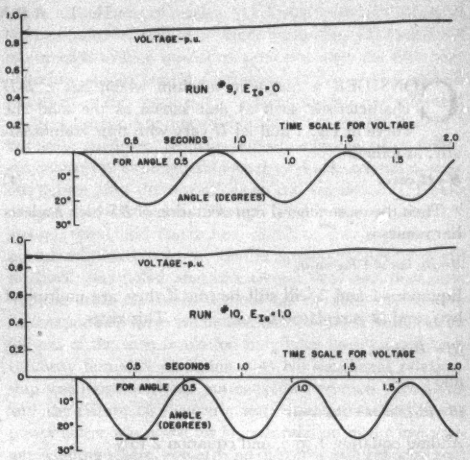

Fig. 1. Voltage dip and condenser swing produced by sudden application of arc-furnace load.

CONCLUSIONS

1. The condenser swing did not increase the voltage dip appreciably. To the contrary, the voltage dip calculated with zero secondary resistance (and no condenser swing) was greater always than that produced by any finite value of secondary resistance, including that value which resulted in the maximum condenser swing.

2. The possibility of condenser instability seems remote if the criterion of conclusion 3 is observed. The buffer reactance was increased to a value such that the total system reactance, viewed from the arc furnace and excluding the condenser, was 50 per cent on the arc-furnace kva base. Even this high value did not show any signs of instability. Thus, the buffer reactance can very probably be considerably increased beyond values which have been used, as long as the condenser has sufficient capability to maintain voltage in the steady state.

3. A conservative criterion for stable operation, as far as disturbances arising at the arc furnace are concerned, is that the buffer (and system) reactance be kept smaller than the effective reactance of the arc-furnace transformer and secondary leads. This criterion is seen to be independent of the condenser reactances.

Digest of paper 55-448, "Voltage Dip and Synchronous-Condenser Swings Caused by Arc-Furnace Loads," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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A Simplified Mathematical Approach to Hysteresis Losses

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CONSIDER a magnetic medium which has a *B-H* characteristic such as that shown as the solid-line curve in Fig. 1 and let H vary with time cosinusoidally, as follows:

$$H = H_0 \cos \omega t \tag{1}$$

Then the most general representation of B which neglects harmonics is

$$B = B_{01} \cos \omega t + B_{02} \sin \omega t \tag{2}$$

Equations 1 and 2 will still be true if they are multiplied by j, and ωt is replaced by $\omega t - \pi/2$. This gives

$$jH = iH_0 \sin \omega t \tag{3}$$

and

$$jB = jB_{01} \sin \omega t - iB_{02} \cos \omega t \tag{4}$$

Adding equation 1 to 3, and equation 2 to 4

$$(1+i)H = H_0 (\cos \omega t + j \sin \omega t) = H_0 \epsilon^{j\omega t} \tag{5}$$

and

$$(1+j)B = (B_{01} - jB_{02}) \epsilon^{j\omega t} \tag{6}$$

With the usual definition of μ, the permeability,

$$\mu = B/H = (B_{01} - jB_{02})/H_0 = \mu_1 - j\mu_2 \tag{7}$$

Equations 1 and 2 define, in general, an ellipse in the *B-H* plane. Thus, the theory developed here amounts to approximating the hysteresis loop by an ellipse, the features resulting from harmonics, i.e., from nonlinearity, being neglected. Such an elliptical approximation is shown as the dashed curve in Fig. 1.

Since $B = \mu H = (\mu_1 - j\mu_2)H$

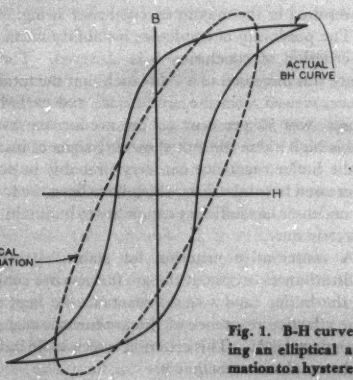

Fig. 1. B-H curves showing an elliptical approximation to a hysteresis loop

in this approximation, B lags H by an angle ψ given by

$$\psi = \tan^{-1} \mu_2/\mu_1 \tag{8}$$

and absolute or rms values are related by

$$|B| = (\mu_1^2 + \mu_2^2)^{1/2} |H| \tag{9}$$

On the other hand, the quantities ψ and $|B/H|$ might be measured; then μ_1 and μ_2 could be calculated and would give the elliptical approximation to the hysteresis loop.

This method also deals approximately with the hysteresis loss in a magnetic structure. Consider a magnetic core of cross sectional area A, mean flux path length λ, and permeability $\mu = \mu_1 - j\mu_2$, with a winding of n turns. If a current I flows in the winding, there will be a field $H = nI/\lambda$ and a total flux $\phi = n\mu IA/\lambda$. At an angular frequency ω there will be an induced emf given by $E = j\omega\phi = j\omega n\mu IA/\lambda$. Since $E = j\omega IL$, where L is the inductance, this corresponds to a complex inductance $L = L_1 - jL_2 = (\mu_1 - j\mu_2) n^2 A/\lambda$.

Moreover, if a current I flows, there will be a power loss W given by the real part of EI, so that

$$W = \omega L_2 I^2 = \omega \mu_2 n^2 A I^2/\lambda \tag{10}$$

Since $\mu nI/\lambda = B$, this gives $W = \omega A \lambda \left(\frac{\mu_2}{\mu_1^2 + \mu_2^2} \right) B^2$ (11)

Here the rms value of B is used. The peak value, B_{max} could be used instead, if a numerical factor of 1/2 is included. Equation 11 shows W to be proportional to the square of B_{max}. It is often considered that the loss varies approximately as the 1.6 power of B_{max}, although for some materials this value is inaccurate. In any event, the expression developed by the elliptical approximation often gives substantially accurate results over a wide range.

In this approximation, because of the effects of hysteresis, as indicated by the angle ψ, I and E are not exactly 90° out of phase, even if resistance in the winding is neglected. This may be of interest in such problems as transformer cores with hysteresis, indicating phase shifts in the transformer due only to the hysteresis.

In conclusion, it has been shown that, to such an extent as harmonics may be neglected, the phenomenon of hysteresis in steady-stage alternating magnetic circuits may be handled by replacing the hysteresis loop by an ellipse. Then calculations can be made with complex numbers, exactly as in alternating electric circuit theory. This method might also be useful in dealing with hysteresis in nonlinear capacitors; or in mechanical systems, with backlash, which is a form of hysteresis.

A special article recommended for publication by the AIEE Committee on Basic Sciences.

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Insulation Systems for Dry-Type Transformers

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THIS DIGEST deals with the experimental application of functional test principles to the evaluation of temperature endurance of dry-type power transformers. The object of the tests described was not to test any specific design of dry-type transformers; rather, it was to give a trial run to a test procedure which was under consideration as a Test Code by a subgroup of the AIEE Working Group on Life of Materials. These, and similar tests made by four transformer manufacturers, along with a background of field experience, were used in formulating the "Proposed Test Code for Functional Temperature Endurance Tests of Ventilated Dry-Type Power and Distribution Transformers."

In accordance with the provisions of this proposed Test Code, 12 test models were built, functionally representing 15-kv class ventilated dry-type power transformers, constructed with class *B* materials. The objects of the tests made on these models were to: (1) test the provisions of the Test Code; (2) determine if the inclusion of a shock test into the test routine will affect the results; (3) determine if power-factor variation with insulation aging may be used to indicate insulation failure; and (4) determine if the Test Code procedure is adequate to detect differences in the materials used in the models.

As a result of preliminary tests on four models, certain modifications in the Test Code were made. With these modifications, and substantially in its present form, the Test Code was applied to the remaining eight models. Test procedure consisted of the following operations repeated in a cyclic manner: (1) temperature exposure, carried out by circulating electric current in the windings of the models for 3 days at 260 C in the hottest spot; (2) cooling, and dielectric tests in dry condition, using the following rms values of alternating voltage applied for 1 minute: high-voltage winding, to low-voltage winding and ground—31 kv; section to section of high-voltage winding—7 kv; turn to turn of high-voltage winding—800 volts; and layer to layer of low-voltage winding (600-volt service)—1,200 volts; (3) exposure to an atmosphere of 90 to 95 per cent relative humidity for 24 hours; and (4) dielectric tests, as already indicated, and power-factor measurements in humid condition.

The aging temperature was selected deliberately to be higher than that recommended by the proposed Test Code in order to reduce the time required to produce failures, which was consistent with the rough and preliminary nature of these tests. It was expected that the average time to failure would be about two test cycles.

The tests were carried through seven cycles; the following is a summary of results: (1) There were no failures of the section-to-section, or the layer insulation. (2) Failures of major high-voltage insulation occurred after the fifth heat exposure, under humid conditions on two of the models, subjected to the shock test; identical models not subjected to shock continue without failure after the seventh heat and humidity exposure; likewise, models constructed of different materials, although subjected to shock, continue without failure after the seventh heat and humidity. (3) Failures of turn insulation (800-volt rms) occurred after the second, third, and fourth heat and humidity exposures on models subjected to shock; on the two models not subjected to shock, one failed after the second heat and humidity, but the other continues without failure after the seventh heat exposure; there are indications that some of the earlier failures of the turn insulation may have been caused by a runaway humidity condition. (4) No significant relationship was found between power-factor variation with aging and the failure on dielectric test; greatest change in the power factor was noted for layer insulation in the low-voltage winding where, actually, no dielectric failures occurred; on turn insulation, the power factor showed no significant change after the second heat and humidity exposures; at the same time, it was found that even on unaged models, power factor is greatly affected by the duration of humidity exposure. (5) Experience gained in carrying out these tests shows that the test procedure specified in the Code is practical from the point of view of laboratory technique; furthermore, it was found that with proper technique, the models used in these tests gave a good representation of the temperature distribution which is obtained in full-size dry-type transformers.

CONCLUSIONS

1. The results show that the test procedure given in the Test Code is practical.
2. Observed life of the test samples (15-kv class models, class *B* insulating materials) agreed with the expected life of Group II apparatus well within the limits of the accuracy of tests.
3. Based on the test data available to date, the test procedure given in the Code appears capable of clear differentiation between insulation structures built of different materials.
4. Tests show that mechanical shock may be an important factor in determining the life of dry-type transformers.
5. To establish this Test Code as an industry Standard, additional tests are required on a sufficiently large number of samples to permit statistical analysis of the data. The tests should include at least ten samples, aged at each of three different temperatures. The results of these tests must be correlated with available field experience.

Digest of paper 55-449, "Functional Life Tests of Insulation Systems for Dry-Type Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Reliability in Complex Electronic Equipment

G. H. SCHEER

As equipment becomes increasingly complex, component reliability becomes more vital. A statistical study of operational failures of various types of electronic components and ways of reducing these failures are presented. Methods for minimizing maintenance problems through the use of plug-in subassemblies are also discussed.

TODAY'S MILITARY AIRCRAFT are highly complicated mechanisms. Every attempt is made to relieve the pilot and crew members of tasks which can be done by a machine. This practice, although advantageous, requires the use of more and more intricate mechanisms. As their complexity increases, the problem of reliability becomes more acute. In order to limit the scope of this paper, only electronic equipment and airborne communications applications will be considered.

In recent years, the advances and refinements in communications equipments have been remarkable. For example, one such equipment provides 44,000 crystal-controlled frequencies using only 10 built-in quartz crystals which are never changed. This refinement has saved the cost of tens of millions of quartz crystals which would have otherwise been required for world-wide military operations. This particular equipment finds the frequency desired and even automatically tunes and loads the antenna. These automatic features have resulted in simplified operation, but also have resulted in the need for extremely complicated circuitry.

The current trend in airplane design is toward smaller airplanes, with more equipment in them. Subminiaturization has thus become a requisite. Past experience showed that complexity combined with all of the new techniques of subminiaturization presented some severe problems. These problems were aggravated by the fact that many more component parts were used than in previous equipments.

When the complex equipment reached the field, the time interval between airborne failures was low, necessitating frequent maintenance and resulting in mission failures. This was of great concern, since communications are vital to the success of any mission and safe return of the aircraft to its base. The Air Force and contractor entered into a concerted program to discover the source of unreliability and to effect the changes necessary to correct the condition.

It was found that the problem was not concerned with the basic electrical design of the equipment. Instead, the high failure rate was caused by failure of individual component parts. Every field and factory failure was carefully analyzed, and eventually a pattern of failures was developed which made corrective action possible.

The Rand formula will serve to illustrate the magnitude of the reliability problem. It is admittedly arbitrary and probably pessimistic, but it certainly indicates the right order of magnitude. Since absolute perfection is an impossibility, it must be assumed that some number of equipment will always exhibit early life failure. For purposes of the formula only, one equipment of every 100 will be assumed to exhibit early life failure. The equipment in question had very close to 2,000 active component parts employed in series. Then: $(1\text{-}0.99)/2{,}000 = 0.000005$. Interpreted, the result states that each individual component part used must have a failure rate not to exceed five per million units. Component parts, particularly the new subminiatures, were not manufactured to such a standard.

Subminiature component parts, including vacuum tubes, were very new to the art, and many had been designed for the specific electronic equipment in question. These components had not had the benefits of product improvement which normally is a gradual process requiring years of refinement, production in quantity, and manufacturing skill. But airplanes had been configured around the new smaller equipments, their automaticity was a definite requirement, and the time-consuming evolutionary process of improvement could not be tolerated.

It was immediately obvious that JAN specifications, written to minimum requirements to permit manufacture by many sources, were inadequate for the more complex equipments. Superior components were needed quickly, and they were needed in novel subminiature forms.

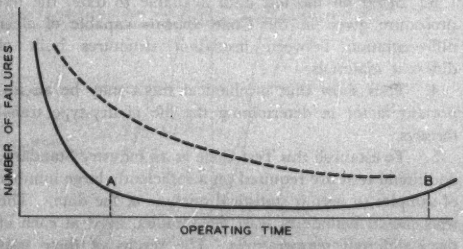

Fig. 1. Incidence of failures as a function of operating time

Revised text of a District paper presented at the AIEE Middle Eastern District Meeting Columbus, Ohio, May 4–6, 1955, and recommended for publication by the AIEE Committee on Electronics.

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APPROACH

THE ENSUING TASK of building high reliability into the complex communications equipments was one of tremendous detail and proportions. To start with, each and every failure was painstakingly analyzed as to cause. Failure patterns became evident, making it possible for the offending components to be classified accurately as to kind and type. In a few instances, component failure was caused by other components in the circuits. Every possibility was critically examined. In some cases, the component part required complete redesign; in other cases, a new design was obtained from a new source. Occasionally it was found that emphasis on quality control was sufficient to bring about the necessary corrections.

Sampling procedures were abandoned, and 100 per cent inspection was instituted not only at the part vendor's plant, but also at the equipment manufacturer's incoming inspection. Sampling was subsequently allowed only after the consistent quality of the component part was established beyond a doubt.

DESCRIPTION OF FAILURES

STRANGELY ENOUGH, many of the faults discovered were quite fundamental and would never have occurred if adequate life tests had been performed initially. Sealed relays performed poorly. In one case, it was found that a volatile hydrocarbon had been used as a coil impregnant, and vapors were given off which could not escape. Sparking at the contacts caused freecarbon to deposit, and soon the electrical contact was erratic. The solution was simple, but a little foresight would have prevented such a design. Sealed relays are still a problem, principally because once sealed, there is no access to the elements. Thus, absolute cleanliness is a necessity.

High-K ceramic capacitors exhibited two types of faults, both corrected through better quality control. First, the silver coating was not applied symmetrically. Because of this, the plating came dangerously near the edge of the capacitor. Second, the outer edges of the silver were often ragged, resulting in possible corona and electrical stresses, which caused gradual deterioration of the capacitor.

In the case of tantalum capacitors, the acid seal deteriorated purely as a time function. No amount of testing for quality could uncover any obvious corrective measures.

As a component part, subminiature vacuum tubes were in a special category. Unfortunately, the model tubes were phenomenally reliable, and it was anticipated that they would be even better when produced in quantity. This assumption was not true, however, and special treatment was required. In some cases, mechanical redesign was necessary; in other cases, specification limits on the parameters were tightened, and testing procedures were altered. Heater thermal shock tests were amplified. New specifications were prepared and became effective in October 1954. Since the military services are almost exclusively the sole users, tubes are not manufactured to any but the new specifications.

As a result of a major carefully controlled field evaluation of equipments built from improved components, the reliability of the new components under actual operational conditions can be examined. The one factor which is missing is the actual population of each component in the equipments. Also, components are not broken down by kinds and classes. Even without these voluminous data some conclusions can be drawn from the statistics based on 79 individual failures which occurred in about 2,800 hours of airborne operation of 33 equipments. The figures in Table I show the areas which require more improvement in order to improve reliability.

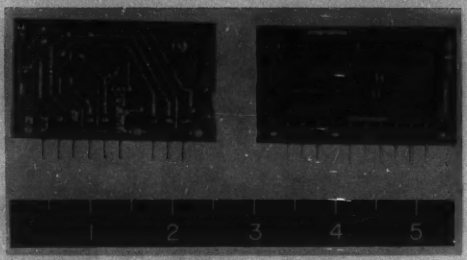


Fig. 2. Subminiature plug-in oscillator showing printed wiring

Table I. Summary of Component Failures

Type of Component		Number of Failures
Vacuum Tubes (All Types)		45
Relays:	Sealed	11
	Unsealed	1
Capacitors:	Tantalum	5
	Paper	1
	Vacuum	1
Switches:	Stepping	2
	Wafer	1
	Input	1
	Aneroid	1
Resistors:	Variable Wire-Wound	1
Filters:	Chokes	2
Miscellaneous:	Plugs	3
	Solenoids	1
	Clutches	1
	Gears	1
	Dials	1
Total		79

There were 93 vacuum tubes per equipment system, of which 67 were of the subminiature type. Among other components, the greatest population per equipment consisted of capacitors, resistors, and relays, the first two being of highest incidence. It is noteworthy that resistors made a good showing in reliability. With the exception of the subminiature tubes which had not been improved when field testing of the equipments began, these results are with improved components, indicating that the job is far from finished.

LIFE TESTING

IT WAS OBVIOUS from the start of the program that quality could not be "tested" into components or equipment; it had to be inherent, and the finished product could be no better than its most unreliable component part. Testing did serve one very useful purpose, however. Some component parts, such as vacuum tubes, often show the highest failure rate in very early life. If they are operated for a considerable period of time before the customer gets

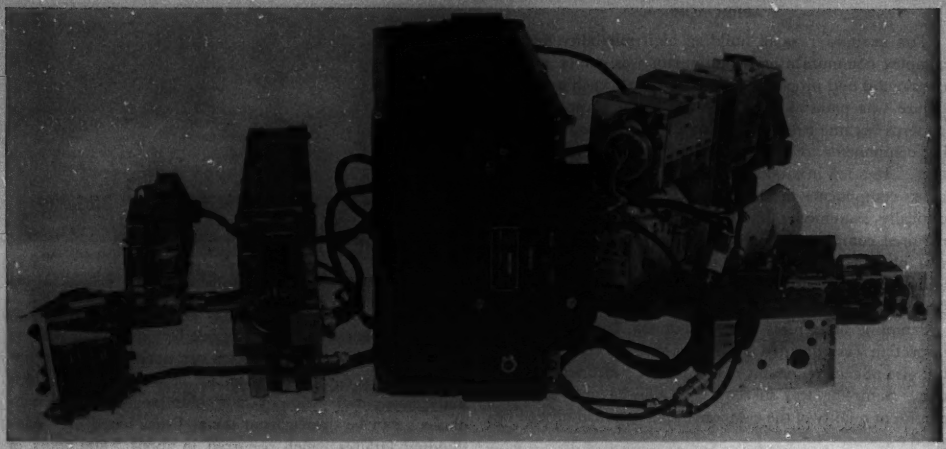


Fig. 3. AN/ARC-34 receiver-transmitter with subassemblies patched

the equipment, the reliability of this equipment is actually increased because most of this type of weakness is culled out during factory testing. Fig. 1 gives a rough approximation of incidence of failures vs operating time of the equipment. Most failures occur in early equipment life, up to point *A* on the curve. Then comes a period of low failure rate and highest reliability, with minimum maintenance required. Failures here are purely random in nature. This plateau is variable in length and height for different types of equipment. It is quite obvious that the ultimate customer should not get the equipment until point *A* is reached in its life span. As the produced equipments become more reliable, point *A* moves to the left and downward, and less factory testing is necessary to cull out early life failures. At point *B* on the curve, the reliability again decreases as the components begin to wear out, and at some point beyond *B*, depending again upon the type of equipment, further maintenance becomes uneconomical. Either the worn-out parts should be replaced or the whole equipment discarded. This is analogous to the point reached with an old car when trade-in is being considered.

The solid-line curve represents the life characteristic of an equipment utilizing improved component parts with good life characteristics. The dashed curve represents an equipment made from poorer quality component parts. It is seen that a plateau region is never attained; the equipment cannot be satisfactorily "debugged" by any amount of factory testing.

On the complex electronic equipment with 2,000 component parts, it was necessary that the factory test time be about 200 hours on each equipment before point *A* on its life curve was reached. The first portion of this test time is a shakedown test, an innovation with this equipment. It consists of operating the equipment for 48 hours without shockmounts, while mounted on a brute-force shake table and vibrated for a period of 10 minutes every hour. Intermittent or complete failures are immediately apparent through instrumentation and listening tests. In a representative number of equipments, 49.2 per cent of the factory failures occurred during this test, attesting to its usefulness. The next test is a final check during which adjustments are made to obtain specification performance. The time involved is approximately 18 hours. Of the factory failures, 11.1 per cent occurred in this operation. The systems test takes about three hours. In this period, 15.9 per cent of the failures occurred. Another half hour of operation is required in quality control testing, in which 6.4 per cent of the factory failures were found. The cold test, in which 7.9 per cent of the total factory failures occurred, involves about an hour of operation. The last and longest test is the 125-hour life test. Only 9.5 per cent of the factory failures occurred here, even though this test represents over one half of the total factory test time. These results indicate that most of the early life failures had already taken place and the weak components removed before this point.

It is quite obvious that the 48-hour shakedown test, with vibration, is very valuable in precipitating early life failures, particularly those caused by poor workmanship, such as cold or unsoldered joints, weak mechanical structures, etc. When testing does not result in significant failures, the testing time may be reduced, since point *A* on the curve has been reached. The previously mentioned 125-hour life test has been reduced to 96 hours, and may be further reduced as the failure rate is reduced.

REMEDIES

PRIMARILY, quality control must be increased above prevailing standards in industry. Sampling procedures cannot be employed to replace 100 per cent parts inspection until the quality level is consistently excellent. More rigid inspection is required at more points during the manu-

facturing processes. Poor workmanship is a perennial problem and its elimination requires continued drastic action. When automation becomes more widespread, this problem may be solved. Test procedures must be revised and augmented, with long testing periods on each and every complete equipment until the failure rate in any one test is insignificant.

At this point the matter of maintainability will be introduced since it is very much involved with reliability. In some respects one offsets the other. While complexity was being added to the equipment to make the pilot's job easier, it could well have been that the job of the maintenance man was being made insurmountable at the same time. Fortunately, this situation has been avoided in the design of complex equipments. The result is that the more complex equipments are easier to maintain, at the two lower maintenance echelons, than previous, less complicated equipments.

DESIGN CONCEPTS

First, the equipments were constructed from a number of separate subassemblies or independent packages. One such subassembly is shown in Fig. 2. Each particular subassembly was interchangeable mechanically and electrically with any like subassembly. Second, each was provided with one or more test sockets, accessible without disturbing any subassembly. By using a simple multimeter with a tapped switch for selecting the important circuit voltages and currents on a "go, no-go" basis, a defective subassembly could be isolated very quickly. In order to remedy the fault, it was necessary only to replace the one defective subassembly with a good spare unit. The faulty subassembly could be repaired later and at a different geographical location, if desired. The use of patched subassemblies is illustrated in Fig. 3.

These two design concepts have proven their worth beyond a doubt, and have permitted an entirely new idea in military equipment maintenance procedures. Heretofore, every echelon of maintenance was permitted to do any and all maintenance within its maximum capability. This meant, among other factors, that spare component parts had to be stocked at every echelon and at every air base; it also meant that procedures between bases would be different, since each would have a different maximum capability. Under the new concept, the lowest echelon, at the airplane, changes only complete black boxes. In this same geographical area, the second echelon trouble shoots on a "go, no-go" basis and replaces complete subassemblies. Thus, the equipment goes back into the airplane in a very minimum of time, a factor of paramount importance in military operations.

Detailed repairs, requiring the highest skill levels, are performed only at the third echelon, the depot. Complete subassemblies are bought as spare packages. Bits and pieces are needed only at the depot level.

CONCLUSION

As a result of the evaluation programs, it was determined that complex equipments, using the new design concepts, and made adequately reliable through better component parts, are satisfactory for the military services.

It was stated previously that superior component parts are most essential. These better grade components must be standardized in some manner, perhaps as a special grade under JAN specifications. So much work has been done and still needs to be done to improve subminiature component parts that industry should avail itself of this pioneer work and carry on the improvement program. The causes for unreliability are no longer mysteries.

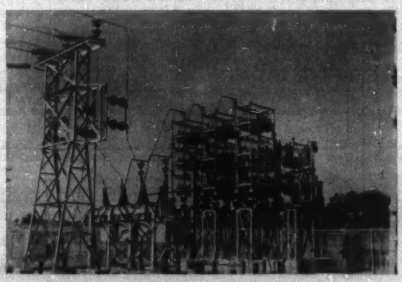
Application of the factors affecting reliability has increased the reliability of one of our complex equipments more than thirtyfold, and this was actually done in a period of about three months, indicating what can be done in this line of endeavor. The areas of unreliability have been described rather briefly in this paper. Of most importance is the maintaining of a suspicious attitude; there must not be any signs of complacency. The least sign of trouble must be thoroughly investigated. Relaxations in testing time should always be on a cautious basis.

Now that the basic answers to reliability are known, and it has been proved that complexity and maintainability can be made compatible, it is hoped the day is not too far distant when most equipment can be installed and forgotten for at least 2,000 hours of uninterrupted operation.

Voltage-Divider-Switching 5,250-Kvar Capacitor Bank is Erected

Installation of a 5,250-reactive-kilovolt-ampere (kvar) capacitor bank that utilizes the voltage-divider-switching method was completed recently by Public Service Company of Oklahoma. Designed by Line Material Company, Milwaukee, Wis., the bank operates at 66.5 kv, has two steps, 3,000/2,250 kvar, respectively, with 5 series groups per step.

The first step acts as a voltage divider; voltage levels are established for each series group, and the potential gradient increases with each successive group. Because the oil breakers and switches operate individually and at slightly different instants the incremental change in capacitance minimizes system disturbance.



Computer for Automatizing Network Analyzers

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THE RECENT ACTIVITY AND INTEREST in the development of computer methods for speeding up the solution of power-system transient-stability problems has prompted the reporting of some work done to accomplish this task on the Massachusetts Institute of Technology (MIT) Network Analyzer.

The solution of a power-system transient-stability problem requires the determination of the rotor position of each synchronous machine in the system as a function of time following the initiating disturbance. In steady state, the rotors run at synchronous speed and therefore are displaced from each other and from a synchronously rotating reference by fixed electrical angles. A fault or other disturbance in the system results in changes in rotor speeds and angular positions; these changes are of interest since synchronism will be lost if the angular displacement between rotors becomes too large.

The change in the rotor angle of a given synchronous machine, following a disturbance, is for practical purposes proportional to the double integral with respect to time of the difference between the mechanical power supplied to the machine by its prime mover and the electric power delivered by the machine to the system. The electric power delivered to the system is a function of the rotor angles of all the machines in the system, the driving-point impedance, and the transfer impedances between the machine under consideration and all the other machines in the system. The differential equations describing the rotor angles are such, that a mathematical solution in closed form exists only in exceptional cases. Hence, nearly all multimachine transient-stability problems are solved on network analyzers using the step-by-step method with its tediousness and accumulated inaccuracies.

Fig. 1 is the block diagram of an experimental computer unit built to operate in conjunction with the MIT Network Analyzer. This unit positions one phase shifter of the network analyzer, in accordance with the solution of the power-system electromechanical differential equations. For a complete installation, one such unit would be required for each phase shifter used in the power-system representation.

The computer solves the mechanical part of the electromechanical differential equation by utilizing power-flow data obtained from the network-analyzer representation. The necessary integrations are performed by the watt-hour meters, while the voltage regulator corrects for the internal impedance drop of the phase shifter and the backlash of the gear train driving the phase-shifter rotor. The magnitude of the voltage E, representing the internal voltage of the machine, is thus held constant, while its phase angle is maintained equal to the computed angle δ.

Part of the computer unit can be used as a power regulator for controlling the phase-shifter power output during steady-state power-flow studies.

Two sample problems were solved with the experimental computer unit. The first was the prediction of the power-angle excursion of a synchronous machine suddenly connected out-of-phase to an infinite bus. For certain initial conditions, there is a mathematical solution in the form of tabulated eliptical integrals. After 1 hour of computer operation, corresponding to 6 seconds of system time, the amplitude of the machine oscillation as given by the computer differed by less than 12 per cent from that obtained from the mathematical equation. Some errors can be eliminated. The second problem was the calculation of the power-angle transient for a single machine following a 3-phase fault and circuit-breaker operation in the transmission network connecting the machine to an infinite bus.

A complete computer installation would consist of a set of computer units, one for each phase shifter, with rotor-angle information fed from each computer unit to a central multichannel recorder. The units would serve as power and voltage regulators for the phase shifters when the analyzer is used for steady-state studies.

Digest of paper 55-5, "Computer for Automatizing Network-Analyzer Operations," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in the AIEE *Communication and Electronics*, May 1955, pp. 208–14.

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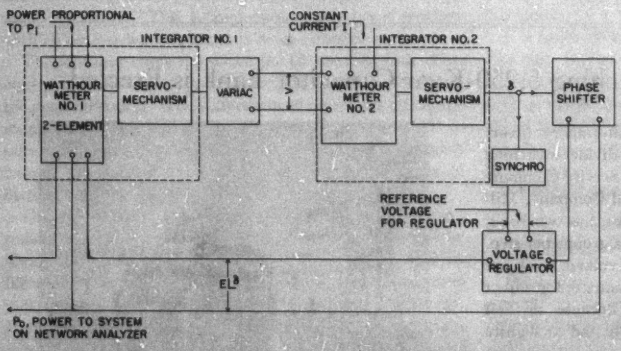

Fig. 1. Block diagram of the experimental computer unit

Temperature Rise of Armature Windings

M. M. LIWSCHITZ-GARIK
FELLOW AIEE

ON THE BASIS of Fourier's equation of heat flow, equations are derived for the temperature-rise distribution along the armature winding and the iron. These latter equations make possible the investigation of the influence of various factors on this temperature rise. They also make possible the computation of the heat flow between embedded copper and end-winding copper, between copper and iron, and between copper and iron and the cooling medium.

The influence of the following factors on the temperature rise of the armature winding and iron, and on the heat flow, is investigated for a typical waterwheel generator rated 35,000 kva, 3 phases, 60 cycles, 64 poles, 13,200 volts, and 0.9 power factor:

1. Air volume through the radial vents.
2. Air volume through the end windings.
3. Voids in the slot portion (embedded part) of the winding.
4. Thickness of the insulation in the slot and end winding.
5. Transverse (axial) heat conductivity of the laminations.
6. Copper losses.
7. Iron losses.

The results of the investigation for items 1 and 2 are shown in Fig. 1 and Tables I and II. Fig. 1 shows, as a function of the air volume in the radial vents, the temperature rises of the winding in the middle of the core and in the middle of the end winding, the temperature rise of the iron in the middle of the core, the errors in the reading of the resistance temperature detector (RTD), and the readings of the RTD. It is seen that a reduction of the air volume through the radial vents causes a considerable increase of the temperature rise of the winding in the middle of the core. The RTD readings lie about 10 C below the actual temperature rises of the winding.

Table I shows the heat flow from the embedded part of the stator winding to the iron (Q_{cu-Fe}), to the gap through the wedges (Q_{cu-g}), to the air in the radial vents (Q_{cu-v}), and to the end winding ($Q_{cu\text{-}end\ winding}$). It is seen that a reduction of the air volume through the radial vents reduces the amount of heat flowing from the embedded copper to the iron and to the air in the radial vents, but increases the amount of heat dissipated by the end winding and the air in the gap.

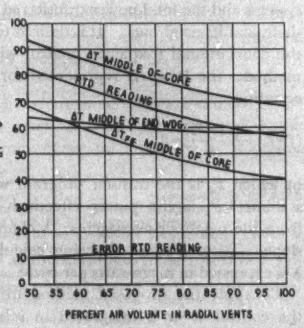

Fig. 1. Influence of the air volume in the radial vents on the temperature rise of the winding and iron in the middle of the core and on the error and reading of the RTD

Table I. Influence of the Air Volume in the Radial Vents on the Heat Flow from the Embedded Part of the Copper to the Iron, to Air in Gap and Vents, and to End Winding

	Per Cent	Per Cent	Per Cent
Air volume in the radial vents	100	75	50
Q_{cu-Fe}	61.2	58.5	51.6
Q_{cu-g}	7.3	7.5	7.8
Q_{cu-v}	25.2	23.9	21.5
$Q_{cu\text{-}end\ winding}$	6.3	10.1	19.1

Table II. Influence of the Air Volume Between the End Windings on the Heat Flow from the Embedded Part of the Copper to the Iron, to Air in Gap and Vents, and to End Winding

	Per Cent	Per Cent	Per Cent
Air volume between the end windings	100	65	30
Q_{cu-Fe}	61.2	63.9	70.5
Q_{cu-g}	7.3	7.5	7.9
Q_{cu-v}	25.2	26.0	27.7
$Q_{cu\text{-}end\ winding}$	6.3	6.2	6.1

It has been found that a reduction of the air volume between the end windings influences little the temperature rise of the winding in the middle of the core, but influences considerably the temperature rise of the end winding. A large reduction of this air volume may move the hot spot from the middle of the core to the middle of the end winding.

Table II shows the same quantities as in Table I. A decrease of the air volume between the end windings forces more heat to flow from the embedded part of the winding to the iron and to the air in the vents and gap, and less heat to flow to the end winding.

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Load-Phase and Load-Phase Tie-Line Energy Control of Power Systems

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This control process, as originated by French engineers, is adaptable to use on a single system or on several interconnecting systems. The author describes the principle and gives examples of this automatic control based on the measurement of the integral of the deviation of the controlled quantity and upon the subjection to this integral of the load of the plants.

THE PROPOSED METHOD for load-phase control and load-phase tie-line energy control applies to the automatic frequency control of an important isolated system, as well as to the simultaneous control of the frequency common to several interconnected systems and of the power transfers between the latter. The main objects are:

1. To reduce the regulation stress of the power plants subjected to the automatic control, through the simultaneous operation of more regulating power plants.
2. To reduce the power fluctuations caused by the control in the transmission lines of an extensive system, by uniform distribution of the regulating power plants.
3. To decentralize the control by putting it in charge of several regulators scattered over the system so as to reduce, in an extensive system, the development of telemetering and remote-control links required by a control operated from a single central regulator.

The proposed method is based upon the following general principle: The difference between the quantity to be controlled and its reference value is integrated in relation to time; when this difference tends toward zero, its integral tends toward a constant value; this value constitutes a parameter to which is subjected the power of each regulating machine.

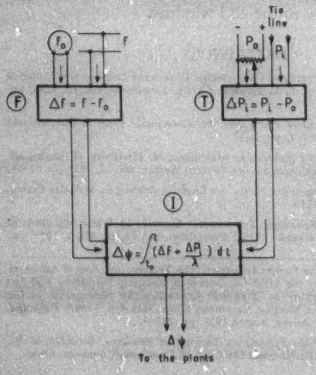

Fig. 1. Basic diagram of a load-phase tie-line energy integrator

FIRST EXAMPLE

IT IS DESIRED to control the frequency f of an important isolated system; f_o stands for its reference value. The difference $(f - f_o)$ is integrated in relation to time; φ_o stands for the value of this integral at the instant t_o arbitrarily chosen as reference, φ for its effective value at an instant t; the integral

$$(\varphi - \varphi_o) = \int_{t_o}^{t} (f - f_o)\, dt$$

constitutes the control parameter. This parameter is an arc or, if preferred, a phase (hence the name of the method). It is expressed for instance in radians or, better still, in multiples of 2π radians; the phase unit is then the revolution (1 revolution $= 2\pi$ radians).

If p_o stands for the mean power of a machine within its regulating band, and p for its effective power, the control law of the subjection of its power to the control parameter, i.e., to the phase difference, is written

$$(p - p_o) + \alpha(\varphi - \varphi_o) = 0$$

or in an abridged form

$$\Delta p + \alpha \Delta\varphi = 0$$

In this equation if $\Delta\varphi$ is expressed in revolutions, Δp in megawatts, α in megawatts per revolution, it characterizes the slope of the subjection characteristic of the machine.

SECOND EXAMPLE

IN THE CASE of several interconnected systems, it is desired to control simultaneously the frequency common to all the systems and the total power transferred between each one of them and its neighbors. It is desired to apply to this effect the conventional frequency control with tie-line load bias method; the latter is represented for one system by the equation

$$(f - f_o) + \frac{(P_t - P_o)}{\lambda} = 0$$

in which P_o is the transfer program with the neighboring systems; P_t is the power effectively transferred to and from the neighboring systems; λ characterizes the control slope. Thus, P_o and P_t being calculated in megawatts, λ is expressed in megawatts per cycle.

To apply the proposed method to this sort of control, the control error is integrated in relation of time; if ψ_o

is the value of this integral at the reference instant t_o, and ψ its effective value at an instant t, the control parameter is constituted by the integral

$$(\psi-\psi_o)=\int_{t_o}^{t}\left[(f-f_o)+\frac{(P_t-P_o)}{\lambda}\right]dt$$

This parameter may be written

$$(\psi-\psi_o)=(\varphi-\varphi_o)+\frac{(W_t-W_o)}{\lambda}$$

where W_o stands for the energy which should have been transferred by the interconnection during the period $(t - t_o)$, and W for the energy which was effectively transferred.

The control parameter is an apparent phase difference equal to the sum of the actual phase difference $(\varphi - \varphi_o)$ and of a term of correction equal to the quotient by λ of the difference of the transferred energy $(W_t - W_o)$.

The control law of the subjection of the power of a machine to the control parameter is then written

$$(p-p_o)+\alpha(\psi-\psi_o)=0$$

or in an abridged form

$$\Delta p+\alpha\Delta\psi=0$$

It has the same form as in the case of pure frequency control, but the apparent phase difference $\Delta\psi$ replaces the actual phase difference $\Delta\varphi$.

CONTROL DEVICE

FIG. 1 SHOWS THE BASIC DIAGRAM of an integrator used for production of the control parameter $\Delta\psi$; it includes essentially a frequency meter F measuring the frequency difference Δf, an apparatus T measuring the difference ΔP_t between the power transferred on the interconnection and the transfer program, and an organ I measuring and integrating the control error to produce a direct voltage proportional to the control parameter $\Delta\psi$. In the case of a pure frequency control the apparatus T is suppressed. It may also be located away from the integrator and linked with the latter by telemetering.

Fig. 2 shows the basic diagram of a regulator utilized for the subjection of the power of a machine to the control parameter $\Delta\psi$.

According to the size and structure of the system and to the geographical distribution of the power plants to be controlled, it is possible to utilize either a single central integrator, or several integrators, each of which may be used to control either a single power plant or a group of several power plants.

When several independent integrators are utilized, their reference frequency must be very accurate and stable (so for this, a frequency generator governed by a crystal oscillator whose accuracy is better than 2.10^{-6} is used).

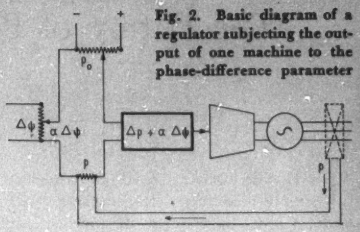

Fig. 2. Basic diagram of a regulator subjecting the output of one machine to the phase-difference parameter

When the system is interconnected with several other systems, the transferred tie-line powers are telemetered to a central point; their sum P is compared with the transfer program P_o by means of the device T of Fig. 1, and the difference value $(P - P_o)$ is telemetered to the central integrator or to the scattered integrators.

The subjection of the powers of the regulating machines to the parameter $\Delta\psi$ can be made according to the diagram of Fig. 2 by utilizing one controller per machine; the parameter $\Delta\psi$ must then be transmitted from the integrator to each of these individual controllers. The subjection can also be made either for each power plant or for a group of power plants. The first method, that of individual subjection, is the better as it leads to less developed telemetering links and to the most simple equipment.

TESTS AND UTILIZATION IN THE FRENCH SYSTEM

THIS CONTROL PROCESS is particularly suitable for the French system which is operated as a single unit by Electricité de France, which has a present peak load of 8,500 megawatts.

The equipment was designed, built, and experimented on in France. The tests were carried out on the load-phase control (equivalent to a pure frequency control) by means of a single integrator, then on two independent integrators. The next tests concerned the tie-line power and frequency control (equivalent to the conventional load-frequency control). For the first series of these tests, the French system was divided into two parts linked together by one or several 225-kv lines, each part being controlled by an integrator. On a second series, the whole of the French system controlled by two independent integrators was interconnected by a 150-kv line to the Belgian system, itself controlled by an integrator.

The tests carried out, considered as a whole, have shown that the control method yielded satisfactory results from the point of view both of the very quality of the control and of the load distribution among the regulating plants. From now on, this control method is being currently applied for the control of the French system with two independent integrators, one of them controlling the steam power plants of the Paris area, and the other, the main hydroelectric plants of the Massif Central. A third integrator will shortly be installed to control two great hydroelectric plants in the Alps. The powers transferred by the French system to and from other countries are or will be measured at the frontiers, then telemetered and totalized.

Revised texts of paper 54-61, "Load-Phase Control," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and paper 55-24, "Load-Phase Tie-Line Energy Control of Interconnected Power Systems," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. The former is published in AIEE *Transactions*, vol. 73, pt. III-A, 1954, pp. 571–7; the latter is published in AIEE *Power Apparatus and Systems*, April 1955, pp. 1–5.

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The Future of Power Transmission in the West

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THE WEST having relied on hydroelectric resources to supply most of its electric energy will in several important areas have to use thermal generation for a large portion of future needs. As an example, consider southwest California, which is the principal load concentration in an area including Arizona and southern Nevada. If long-time growth rates continue, a load of 12.5-million kw may develop by 1975, with only 3.1-million kw of ultimate hydro resources. With a total energy requirement of 71.2-billion kwhr and only 16.4-billion kwhr from hydro, 77 per cent of the energy would have to be supplied by thermal generation.

Coal in eastern Utah offers an adequate supply of thermal fuel. Oil and natural gas now transported by pipe line may be limited for future generation by increasing cost and other demands. Generation from atomic, solar, tide, and wind resources require further development to be economically competitive in sufficient quantities.

Since transportation represents a large portion of coal cost, it appears desirable for the electrical industry to continue investigations comparing electric transmission with other means of transportation; rail hauling being the principal competitor in the case of western coal.

Two coal freight rates exist between Utah and California, one for usage in California and a lower "export" rate for off-loading into ships. It appears that the export rate, $5.39 per ton in 1952, might be obtained for very large shipments. Using an even lower rate of $5.15 per ton for comparison with electric transmission gives a coal hauling cost of 2.19 mills per kwhr.

However, two factors complicate the economic picture for hauling coal. First, the present export rate may not be in balance with respect to cost of new investments, remembering that freight rates are regulated by a complicated set of rules. Since 1940 construction costs for transmission lines and substations have doubled while coal freight rates only increased 36 per cent. Second, compared with an annual requirement for hauling 22.5-million tons, the railroads in 1949 had only sufficient rolling stock to move approximately 2-million tons annually. It would appear that extensive new railroad investment might change the relationship between construction costs and freight rates approaching that existing in 1940. If the 1940 freight rate of $4.26 per ton were doubled, rail transport would cost about 3.57 mills per kwhr.

Fig. 1 shows a schematic power-flow diagram for electric transmission. Only 4.2-million kw, 45 per cent of the thermal generation required, is transmitted electrically with the balance, 5.2-million kw, located in the load area.

The sending-end system might consist of several power plants connected to a central switching station. The six transmission lines were each composed of two 330-mile sections of 500-kv duplex-conductor lines. This voltage was selected without detailed studies. It appears likely that 500 kv will become feasible, and individual line capability appears reasonable compared with total area load and annual load growth. The single compensating and switching station in the center of the lines having about 50-per-cent compensation provided a transient stability limit of 750 megawatts per line. The shunt reactors were required for heavy as well as light load.

Cost studies indicated an economic line loading of 700 megawatts per line which was below the transient stability limit for six lines in parallel. During the first few years when fewer lines are required, transmission costs would be higher than for the major portion of the project life. Base load operation of mine area plants, near 80-per-cent load factor, would be essential to economic justification.

The annual charge obtainable for such a project affects transmission costs considerably. Using an over-all annual charge of 6.5 per cent, cost of electric transmission was 2.19 mills per kwhr. The break-even rate with $4.19 per ton freight cost was 7.6 per cent. Doubled 1940 costs make it about 14.6 per cent.

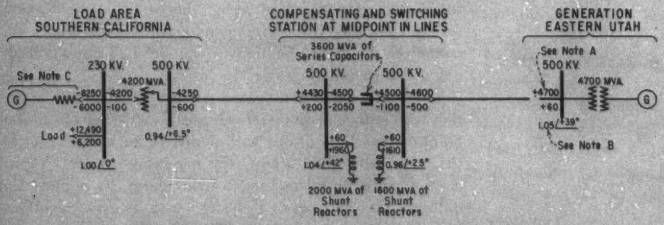

Fig. 1. Transmission of 4.2-million kw at 500 kv over 6 lines, 660 miles long compensated to an equivalent length of 300 miles. *A—Power is shown in megawatts above the line and in megavars below the line. A positive sign indicates flow from a bus. B—Operating voltages are shown in per unit of designated bus voltages. Angles given with bus voltages are relative to 230-kv load-area bus. The compensating station decreases over-all angle between the sending station voltage and the receiving station voltage. C—Receiving system represented by equivalent machine, impedance, and load. Synchronous condensers included in equivalent. Total equivalent load is supplied by hydro and steam generation in load area and 500-kv transmission*

Digest of paper 55-184, "A Look to the Future of Power Transmission in the West," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Power Apparatus and Systems*, August 1955, pp. 591–600.

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Effects of Corona on Traveling Waves

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THE effect of corona on traveling waves is to retard any given point on a voltage wave above the corona threshold value by an amount proportional to the distance traveled. Thus the effect is equivalent to a reduction in velocity. If a linear circuit can be characterized by assigning to it a certain inductance L and capacitance C, per unit length, then a wave impressed upon such a circuit will propagate along the circuit with a velocity v, such that

$$v=1/\sqrt{LC} \tag{1}$$

This relation indicates the possibility of explaining corona effects by an increase in capacitance.

The results of laboratory tests show that the corona characteristics under impulse conditions can be approximated by a variable capacitance. Oscillograms of charge vs voltage show that with increasing voltage the trace is essentially independent of the front of the wave and the time to reach crest.

In Fig. 1*A* the fundamental q-e curve of the conductor is shown. The slope of this curve is given by the $C+\Delta C$ curve. The $C+\Delta C$ curve in turn permits the determination of the velocity by replacing C by $C+\Delta C$ in equation 1.

$$v=\sqrt{\frac{1}{L(C+\Delta C)}}=v_L\sqrt{\frac{1}{1+(\Delta C/C)}} \tag{2}$$

where v_L is the velocity of light, which is correct for the front of the wave.

Fig. 1*C* shows an arbitrary volt-time curve which is applied at $x=0$. Assuming that the traveling wave has moved a distance d, the undistorted portion of the wave below the corona threshold voltage, e_0, requires a time $t_1=d/v_L$ to travel this distance. A point on the voltage wave above e_0 will require the time $t_1+\Delta T$. This total time is related to the instantaneous velocity corresponding to the particular point on the voltage wave by the relation

$$t_1+\Delta T=\frac{d}{v}, \text{ or } \Delta T=\frac{d}{v}-t_1=\frac{d}{v}-\frac{d}{v_L}$$

$$=d\left[\sqrt{L(C+\Delta C)}-\sqrt{LC}\right]=d\sqrt{LC}\left(\sqrt{1+\frac{\Delta C}{C}}-1\right) \tag{3}$$

$$\frac{\Delta T}{d}=\frac{1}{v_L}\left[\sqrt{1+\frac{\Delta C}{C}}-1\right] \tag{4}$$

The curve for $\Delta T/d$ is plotted in Fig. 1*A*, and for convenience is replotted in Fig. 1*B*. To determine the retardation ΔT, multiply the value in Fig. 1*B* by the distance traveled. This provides the curve shown in Fig. 1*C* for $x=d$. Thus, a method is available for determining the distortion of a wave traveling on a line whose q-e characteristic is known.

Using the laboratory determined values of ΔC for a particular conductor, the quantity $\Delta T/d$ was computed. These results checked the independently derived retardation curves, $\Delta T/d$, for the same conductor, obtained during field tests on the 500-kv lines at the Tidd power station.

With this characterization of corona, it is possible to devise analogues which can be used for computer studies or analytical work. An incremental element of a line can be represented by a combination of an inductance, capacitors, a battery, and a rectifier.

Under corona the voltage and current no longer have the same wave forms. It is possible to calculate the current wave in terms of the voltage and characteristics of the conductor. It should also be noted that the voltage-time and the voltage-distance wave forms are no longer related under corona conditions, as they are below corona, by the simple distance-time relations corresponding to the velocity of light.

Digest of paper 55-453, "Effects of Corona on Traveling Waves," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Power Apparatus and Systems*, October 1955, pp. 858–72.

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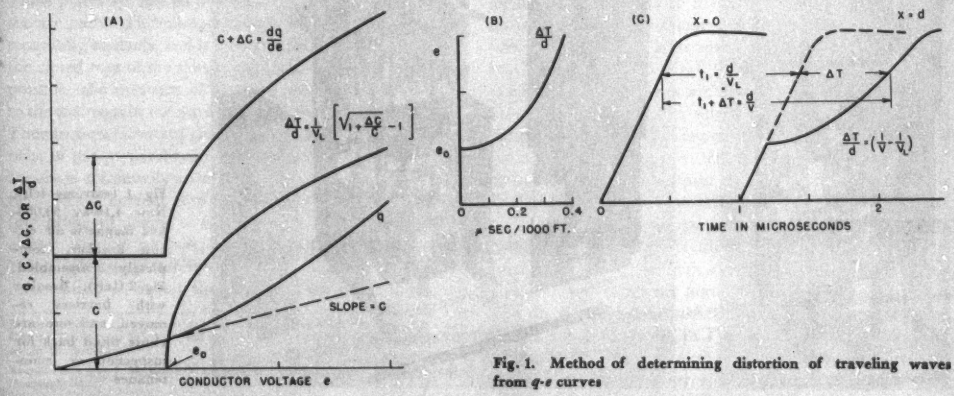

Fig. 1. Method of determining distortion of traveling waves from q-e curves

A New 5-Kv 50,000-Kva De-ion Air Circuit Breaker

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Continuous development work on magnetic air circuit breakers has produced many outstanding changes, as is demonstrated by this electrically and mechanically improved design. Its better operation and reliability is verified by test data.

AIR CIRCUIT BREAKERS for power voltages were first introduced to the electrical industry in 1929 with the multiple-cathode De-ion breaker rated at 15 kv, 500,000 kva.[1,2] The magnetic De-ion air breaker, first produced in 1939, marked an advance in simplification, compactness, and flexibility of design to meet a wider range of interrupting requirements.[3] During the intervening years, air breakers have become an accepted standard, chiefly because of increased safety, cleanliness, low maintenance requirements, and dependable and fast operation. Development work has been continuous to make further improvements in magnetic air breakers.

An example of this work is a new design 4.16-kv 50,000-kva De-ion air circuit breaker, as illustrated in Figs. 1 and 2. Outstanding features of this new breaker are:

1. Smaller and lighter weight hinged-type arc chutes.
2. Reduction in weight for greater ease of handling.
3. Improved long-life contacts.
4. Increased striking distances to ground and across open contacts; full 60 kv across the open breaker.
5. Improved accessibility for inspection and maintenance.
6. Advanced design air puffer for quick interruption of low currents.
7. Individual pole unit subassembly for easy removal for maintenance or replacement.
8. Advanced design low-energy trip solenoid operating mechanism.

THE INTERRUPTER

THE ARC-INTERRUPTING ELEMENT, or arc chute, is the key factor in air circuit-breaker design. For a given inter-

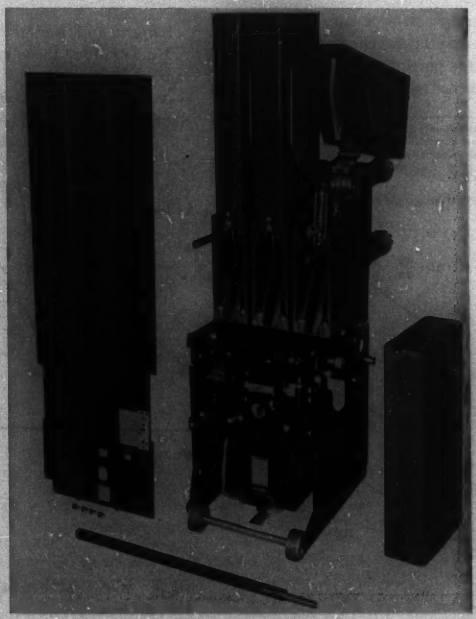
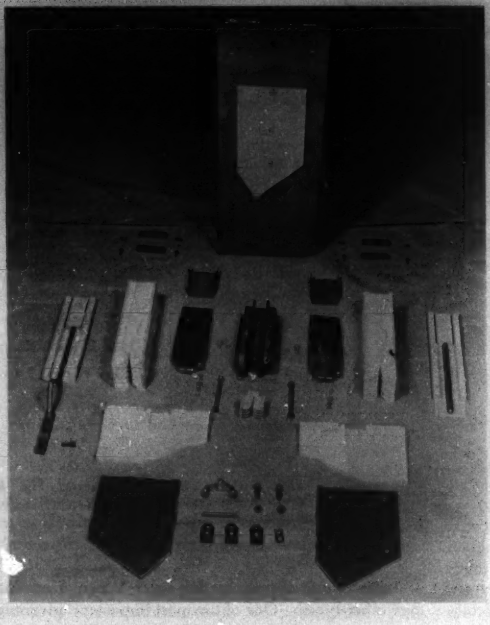


Fig 1 (extreme left). New 4.16-kv 50,000-kva magnetic air circuit breaker, completely assembled. Fig. 2 (left). Breaker with barriers removed, and one arc chute tilted back for inspection or maintenance



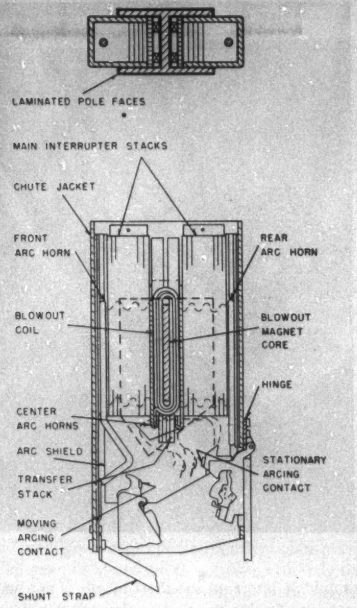


Fig. 3. Completely assembled new design arc chute and component parts. Fig. 4. Cross section of arc chute, showing component parts and arc travel

rupting performance, the characteristics of compactness, lightness in weight, and simplicity are true measures of interrupter efficiency. Reduction in arc-chute size results in smaller over-all breaker dimensions and, consequently, smaller building-space requirements.

In this new design of breaker, the arc chute functions on the basic principle of magnetic de-ionization, explanation of which has been previously presented,[4] and briefly is as follows: "The arc chamber consists of a number of non-gas-forming insulating plates having V-shaped slots. These plates are spaced apart and placed at right angles to the arc path. During operation, an arc is drawn between separating contacts, and is then magnetically moved toward the closed tops of the slots in the insulating plates. At this position, the presence of a strong magnetic field imparts to the electrons in the arc an upward component of velocity. They in turn bombard gas particles and produce an actual blast of gas perpendicular to the arc. This action requires the arc to continually ionize fresh gas in considerable quantities. When current zero is reached, this action continues in a sufficient degree to effectively de-ionize the arc. Dielectric strength is consequently established."

It has been found by extensive controlled laboratory interrupting tests that the design of the blowout magnet and the arc de-ionizing chamber must be carefully coordinated; in general, the more intense and uniform the magnetic field, the more compact the de-ionizing chamber can be. In this design, it was found that a magnet assembly shaped in the plan view like an H, with the blowout coil on the crossbar of the H, provided the most efficient design. Fig. 3 shows a completely assembled arc chute of the new design together with its component parts, and Fig. 4 shows a schematic cross section.

The blowout coils, which are wound around the cross-member of the H-shaped magnet, are in the center of the arc chute. Their terminals are connected to center arc horns, which are in the circuit only during the interruption, and at all other times are at a floating potential. The main interrupting plates are grouped together in two sections and placed to either side of the center arc horns. At the extreme ends of the arc chute are two more arc horns connected to the opposite terminals of the breaker. The main interrupting plates and arc box liners are made from fired refractory zircon porcelain, and there is no asbestos-containing material across potentials.

When the contacts part and draw an arc, it bows upward because of the loop circuit through the contacts and impinges on the center arc horns, forming terminals thereon. The single arc is then broken into three parts, shown by the second arc position in Fig. 4. Several small transfer plates, similar in design to the main interrupting plates, are placed between the lower ends of the center horns; these

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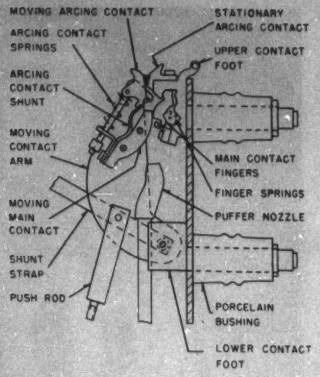

Fig. 5 (left). Breaker contacts. Fig. 6 (above). Breaker contacts, showing component parts

plates quickly interrupt the short length of arc between the center horns, forcing the current through the blowout coils, which energizes the magnetic field. The magnetic field then causes the terminals of the arc which are on the arcing contacts to transfer to the outside arc horns. The arcs are then driven up into the stacks and interrupted in the conventional manner.

Fig. 7. Lower rear of breaker, showing diaphragm puffer

An arc chute of this type has several distinct advantages over other types. One of the most important advantages is better voltage distribution. This places less stress on the insulation, and results in a higher impulse strength for a specific rating. When a breaker is standing in the open position, the voltage across the interrupter appears between the arc horns at the opposite ends of the arc chute. The magnet, being an electric conductor, is all at the same potential, and the over-all voltage appears as a voltage between the two arc horns and the magnet. The new interrupter with an H-shaped magnet has blowout coils which are floating except during interruption. This means that the capacitances of the magnet to the two arc horns are approximately equal, and the voltage divides more nearly equally between the two ends of the arc chute. Voltage stress on the insulating arc-chamber enclosure, thus, is reduced to a minimum.

Other advantages also accrue from this design. In a conventional U-shaped iron magnet, the magnetic field is strongest near the blowout coil and decreases with the distance from the coil. By proper proportioning of blowout-magnet iron, core iron, and coil turns, completely adequate and successful magnetic de-ion breakers have been developed.[6] Many thousands of these breakers are in satisfactory service. By dividing the interrupter into two sections, placed to either side of the blowout coil, a stronger and more uniform field is obtained and less iron is required. This results in a size and weight reduction; also splitting the arc into two sections makes the arcs shorter and, consequently, easier to control.

The reduction in size and weight of the arc chute has permitted adding a feature previously used only on low-voltage breakers and contactors; that is, interrupters hinged to the upper contact. By removing one bolt, the

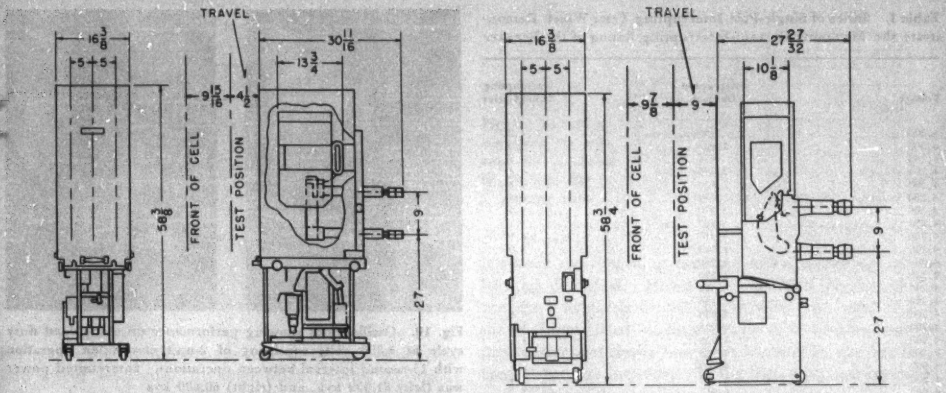

Fig. 8 (left). Former design of air circuit breaker. (right) New design of air circuit breaker, showing increased striking distance and travel resulting from smaller size and better arrangement

arc chute may be tilted back for easy inspection and maintenance, as shown in Fig. 2; and, by removing the hinge pin, the interrupter may be completely removed from the breaker.

Other features which contribute to efficient performance, such as proper streamlining of the arc path, proper plate thickness and spacing, proper slot shape, etc., have been worked out by a long series of empirical tests. These, combined with the advantages of the structure just described, have resulted in an interrupter which is 60 per cent of the size of its predecessor, yet retains ample interrupting ability.

THE CONTACTS

NEW CONTACTS were also designed for the new breaker. They are shown in Fig. 5, and in the schematic diagram Fig. 6. These contacts are of the self-aligning multiple-line butt type. When the contacts begin to separate, the current is transferred from the main current-carrying contacts to the arcing contacts, which are protected from erosion by inlays of silver tungsten. As the arcing contacts part, the current path through the contact structure causes the arc to loop up into the arc chute. The lower end of the blowout magnet is also designed to attract the arc up into the transfer stack where that portion of the arc between the center arc horns is extinguished, placing the blowout coil in series with the arc. The current path is then from the upper stud, through the rear arc horn, through the rear arc section to the blowout coil via the center arc horn. From the blowout coil, the current path continues through the front section of the arc to the front arc horn and by way of the shunt to the lower bushing stud.

The main current-carrying contacts are made up of a solid moving member and a stationary member, consisting of four self-aligning fingers. For the arcing contacts, the flexible member is on the moving-contact arm, thus giving faster parting of the main contacts by taking full advantage of inertia of the contact masses.

The entire contact assembly for a single pole unit is mounted in a molded U-shaped channel. The channel is molded from a high-strength flame-retardent glass-polyester resin. This permits mounting the bushings directly on the molded channel without the conventional metal flanges on the bushings, resulting in further reduction in the over-all size of the breaker and adding to the general safety by placing grounded metal farther from live parts.

Three such assemblies of moving and stationary contacts, in their individual channels, are mounted on the breaker frame. The only tie between the three pole units is the cross-bar which operates the contacts from the mechanism. This makes it very easy to change a complete pole of the breaker without disturbing the setting of the other two poles. The entire contact structure was designed to make contact maintenance easy. The complete moving contact assembly can be removed for servicing by removing two bolts. The stationary arcing and main contacts can be dismounted by the removal of three bolts.

A portion of the stationary contact is extended above the channel to form a part of the hinge; the other portion of the hinge is mounted on the back end of the arc chute. In this way, the arc chute is hinged to the contacts. When the arc chute is down over the contacts, the contacts are completely surrounded. To inspect the contacts or arc chute, it is only necessary to open the shunt connection to the front arc horn, and tip the arc chute back. The contacts are then completely exposed and mounting bolts accessible.

THE PUFFER

IN ADDITION to interrupting maximum amperes in a few cycles, a circuit breaker must also be capable of interrupting magnetizing currents, which may be only a few amperes. A properly designed breaker will give dependable performance on currents of this magnitude without an auxiliary device, but the arcing time will be longer because the arc moves slowly. To obtain fast action for all currents, an auxiliary device has been added.

Table I. Series of Single-Pole Interrupting Tests Which Demonstrate the Maximum Current-Interrupting Rating of the Breaker

Voltage	Interrupted Current	Interrupting Time, Cycles
4,200	995	4.2
4,200	1,005	5.0
4,200	970	5.1
4,200	2,470	4.4
4,200	2,470	4.4
4,200	2,470	4.4
4,200	3,270	3.9
4,200	3,360	3.7
4,200	3,210	4.1
4,200	4,240	3.9
4,200	4,240	3.6
4,200	4,370	3.5
4,200	4,990	3.8
4,200	5,180	3.7
4,200	4,990	3.8
4,200	4,925	3.9
4,200	4,925	3.6
4,200	4,925	3.7
4,800	4,800	3.5
4,800	4,800	3.5
4,800	4,860	3.7
2,400*	16,400	3.6
2,400	15,900	3.5
2,400	15,200	3.7

* Oscillogram of this test is shown in Fig. 9.

Table II. Series of Single-Pole Interrupting Tests Which Demonstrate Performance at Maximum Design Voltage

Voltage	Interrupted Current	Interrupting Time, Cycles
4,800	995	4.9
4,800	1,020	5.6
4,800	2,640	4.0
4,800	2,640	4.7
4,800	4,680	4.4
4,800	4,680	4.3
4,800	5,820	4.1
4,800	5,820	4.3
4,800*	7,040	4.3

* Oscillogram of this test is shown in Fig. 9.

Past practice has been to attach an auxiliary air cylinder, or puffer, to each pole to provide a puff of air as the contacts part to move the low-current arc more rapidly up into the arc chute.

A new type of puffer has been developed which provides a more simplified and efficient construction. This new

Fig. 9. Oscillograms of single-pole interrupting tests at (left) 7,040 amperes, 4,800 volts, and (right) 16,400 amperes, 2,400 volts

Fig. 10. Oscillograms showing performance on a standard duty cycle at 4,800 volts consisting of 2-unit close–open operation with 15-second interval between operations. Interrupted power was (left) 61,800 kva, and (right) 60,600 kva

puffer consists of a single cavity mounted in the breaker frame. Instead of a closely fitted piston, the moving member is a molded rubber diaphragm which is pulled into the cavity by a link to the mechanism. The air expelled from the puffer chamber is led to the contacts through three tubes. On the ends of these tubes are placed three molded nozzles which direct the air across the contacts. By co-ordinating the breaker speed with the nozzle shape and position relative to the contacts, it was possible to make the new breaker have an interrupting time of under 8 cycles over the entire range from very low currents to high short-circuit currents. Fig. 7 shows the rear of the breaker, including the puffer diaphragm.

THE BREAKER

IN ADDITION to being improved electrically, the breaker has also been redesigned mechanically for reliability and longer mechanical life. The puffer, in addition to supplying air for low-current interruptions, serves as a frame mem-

Table III. Typical Series of 3-Phase Interrupting Tests

Voltage	Interrupted Currents			Interrupting Time, Cycles	Kva
	Phase 1	Phase 2	Phase 3		
4,800	650	630	414	4.1	5,540
4,800	592	787	448	4.0	6,660
4,800	576	734	489	4.0	6,180
4,800	1,590	1,600	1,980	3.5	16,650
4,800	1,660	2,160	1,400	3.2	18,200
4,800	3,030	3,520	4,010	3.5	33,500
4,800	3,770	3,560	3,025	3.5	32,000
4,800	3,900	5,110	4,840	3.4	42,800
4,800	4,745	3,865	5,180	3.6	43,100
4,800	4,800	6,260	4,940	3.4	51,600
4,800	6,220	4,660	5,780	3.2	52,400
4,800	4,960	6,370	5,540	3.2	52,600
4,800	5,270	5,120	6,250	3.6	51,400
4,800	6,010	5,350	6,750	3.4	49,600
4,800	7,280	5,120	5,860	3.4	60,100
4,800	5,270	6,830	7,360	3.1	61,800*†
4,800	6,540	5,240	7,350	3.3	60,600*†
2,600	11,100	19,200	15,550	2.8	85,400*
2,600	14,420	15,780	11,510	3.0	69,400*

* Standard duty cycle consisting of 2-unit close–open operations with 15-second interval between.

† Oscillogram of this test is shown in Fig. 10.

NOTE: Additional interrupting capacity is provided to allow for higher interrupting current, occasioned by interrupting times substantially less than rated time of 8 cycles.

Table IV. Withstand Values from a Series of Impulse Tests Made Across an Open Breaker*

Test Number	Conditions†	Polarity	Withstand Voltage
2350–7	Bottom terminals and frame grounded, surge top terminals	Positive	68
			67
			67
2350–9	Top terminals and frame grounded, surge bottom terminals	Positive	71
			71
			71
2350–12	Top terminals and frame grounded, surge bottom terminals	Negative	70
			71
			71
2350–14	Bottom terminals and frame grounded, surge top terminals	Negative	71
			71
			71

* Oscillogram of these tests is shown in Fig 1.
† NEMA Standards require 45 kv under the above conditions.

ber and as a main support member for the individual pole unit assemblies. Also, the plate which mounts the mechanism, the operating solenoid, and all the auxiliary devices serve as a cross member of the frame. Even the wheel axles have been called upon to do double duty. All of these double-functioning pieces contribute greatly toward reducing the size and weight of the new breaker.

These breakers are built only as removable units for metal clad switchgear. When adding to existing switchgear, it is desirable that the external dimensions of the new units be the same as those of the superseded design. Therefore, the reduction in the size of the breaker has been used to increase the travel of the breaker unit between the operating and test positions. In the test position, the breaker terminals are completely withdrawn from the receptacles in the cell, and their openings are covered by a grounded metal-shutter sheet. The reduced size permitted more liberal clearances between live parts and ground. The interior of the cell

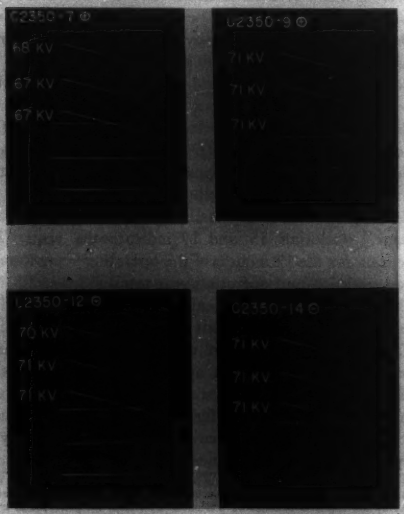

Fig. 11. Oscillograms of impulse tests across an open breaker. Crest voltages are given beside the traces

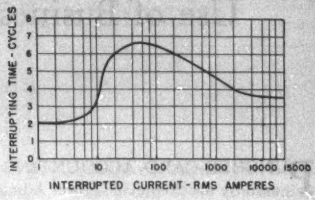

Fig. 12. Interrupting time vs current for a series of 3-phase interrupting tests

has been rearranged to take the fullest advantage of the features described. However, a modified version of the breaker is available for use in the older type cells. Fig. 8 shows dimensioned outlines of the new breaker and its predecessor and shows how the reduction in size has been used to provide increased striking distances, and increased travel between the operating and test positions.

TEST DATA

THIS NEW DESIGN BREAKER, as in the development of all magnetic De-ion breakers, was tested extensively for interrupting performance over the entire range of currents from a few amperes to above the maximum interrupting rating.

Tables I and II list two series of single-phase tests, and Fig. 9 shows two oscillograms selected from the group.

Table III lists a series of 3-phase interrupting tests with oscillograms of a standard duty cycle shown in Fig. 10.

Table IV lists withstand values from a series of impulse tests, both positive and negative, made across an open breaker, and Fig. 11 shows the cathode-ray oscillograms of the test.

Low-current performance is shown in Fig. 12 by a curve of current vs time for interruption. The values used to plot the curve were taken from a series of several hundred tests over the low-current range, and the values plotted are the maximum time observed in the series. All current values were limited by reactance and so have low power factor.

CONCLUSIONS

A NEW INTERRUPTER for magnetic De-ion circuit breakers has been developed which is more compact in size and lighter in weight. At the same time, improved interrupting performance and increased insulation strength has been obtained.

This new interrupter has been built into a new circuit-breaker design for high-repetitive operation and simplicity of inspection and maintenance.

The performance of this breaker has been verified by extensive tests under many conditions, and typical test data has been presented to substantiate this performance.

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Use of Business Machines for Load Forecasting

J. G. GRUETTER

PUNCHED-CARD ACCOUNTING EQUIPMENT is used by the Bonneville Power Administration (BPA) in the calculation and tabulation of load forecasts.

As a wholesaler of electric power, BPA serves 87 different distribution systems, 12 Federal agencies, and 17 industries over 6,565 circuit miles of transmission lines at 322 different points of delivery. The service area embraces Oregon, Washington, northern Idaho, and western Montana. At BPA, one section is responsible for the preparation of load estimates used by the various departments, such as the system engineering, budget, operations, customer service, and rate departments. The repetitive use of one basic estimate for all purposes makes it suited for machine methods.

The load of most utilities consists of the total requirements of ultimate consumers. The power wholesalers' load, however, is determined primarily by the total of the requirements (load less generation) of its utility customers. Therefore, three sets of data are coded for each distributor: (1) its own load estimates; (2) its system resources; and (3) its system requirements. Both peak and energy estimates are prepared by months for a 10-year period and entered on a punch card (Fig.).

In the first three of the 80 columns on the punch card, every electrical distributor in the Pacific Northwest and every BPA customer is assigned an identification number. Thus, total Pacific Northwest area loads, resources, or requirements on the BPA system can be machine selected.

Column four is used to designate the particular BPA area or district office in which the loads, resources, or requirements are located for administrative purposes.

Columns five through seven are reserved for the identification of substations or delivery points. Thus, estimates for 10 years in the future can be compiled for the 322 different delivery points for purposes of customer service planning.

Columns eight and nine, designated "Type of Customer," distinguish loads, resources, and requirements of different categories of customers, so that data can be selected in accordance with operating and contractual arrangements.

Column 10 is used to record generating capabilities. The steam and hydro resources are distinguished, with hydro capabilities being calculated and punched for both minimum- and median-month stream-flow conditions.

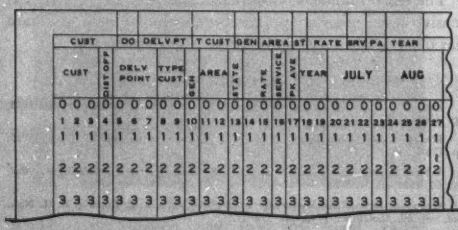

Fig. 1. Arrangement of coding system on punch card

As the most critical time, from the standpoint of resources, is the storage-release period of each year, the total energy load must be related to the available resources in the same period. The number of months included in the period differs between minimum- and median-month hydroelectric conditions, and with different levels of storage development. The average of the monthly energy loads and resources included in the storage-release periods is calculated for each utility and punched into the individual card by the International Business Machine's 602-A calculating punch. Comparisons are thus made between total available resources and total loads.

Columns 11 and 12 are used to indicate the 44 major substation areas on the BPA system out of which power is distributed to the 322 delivery points.

There are many factors affecting line loadings, such as seasonal diversity of loads, diversity of stream flows, variations in loadings arising from the operation of a co-ordinated system of storage reservoirs, and contractual arrangements. Since it is necessary in transmission studies to select a number of different months throughout each year under different stream-flow conditions in order to determine the heaviest loadings on different parts of the system, the combining of substation loads by machine methods is useful.

Columns 11 and 12 are also used when the ultimate delivery is made over the facilities of other utilities to whom identifying numbers have been assigned. "Wheeling" loads may thus be compiled by the respective transferring agents. Column 13 is used to select data by states.

Columns 14 and 15 are used to indicate the appropriate rate in rate studies and pay-out analyses.

Column 16, entitled "Service," is used to classify four basic types of service: direct; coincidental transfer; non-coincidental transfer; and transfer service for other utilities, also known as "reverse wheeling."

Column 17 is used to classify all data into peak and average. Columns 18 and 19 indicate the year. The basic data for the 12 months of the operating year, storage-period statistics, and operating-year totals follows.

The method described makes it possible to conduct accurately many investigations and studies with a limited staff. A primary object in designing a coding system is flexibility. The broadest application of the method is possible when a single basic estimate is used for all purposes, so that information required for a particular report or study, which may range from a revenue analysis to an a-c analyzer study, can be readily machine-selected and tabulated.

Digest of paper 55-630, "The Application of Business Machines to Electric Utility Load Forecasting," approved by the AIEE Committee on System Engineering and recommended by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Transactions*, vol. 74, pt. III, 1955, pp. 854–8.

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Engineering Multistage Diode Logic Circuits

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A LOGIC CIRCUIT is defined as a collection of coincidence and mixing circuits, "and" and "or" circuits, used in a computer or switching system to make a decision based on the condition of the input leads and memory of the system. Such circuits can be realized simply with the use of semiconductor diodes.

Figs. 1*A* and 1*B* show diode "and" and "or" circuits using negative input pulses. (The need for inhibiting gates is removed if the negatives or primes of all input or memory conditions can be generated externally to the logic circuit.) The output of the "and" circuit remains positive (passive) unless all inputs are negative, in which case the output can go negative (active). The "or" circuit output remains positive until any input goes negative, at which time the output will go negative.

Gates can be designed so that the output of one gate can serve as the input to a second gate. Some change in impedance level is necessary to accomplish this; the ratio between the two impedance levels is a function of the ratio of the required voltage swing to the supply voltage, as well as of the degree to which the diodes are nonideal. (An ideal diode is defined as one with zero forward impedance and infinite reverse impedance.)

A multistage logic circuit is one in which one gate feeds a second gate, thus coupling in other inputs, which in turn feeds a third gate—until some gate is reached which is coupled to an output device. In most computer or switching circuits, only two stages of logic circuits are used before an amplifier is inserted. This means using intermediate amplifiers, or reducing all logic operations to two stages, by using extra diodes. In either case, a cost penalty must be suffered. With the use of transistor circuits as input devices, it is felt that intermediate amplification may not be necessary, since transistor pulse amplifiers can readily supply relatively large amounts of pulse power.

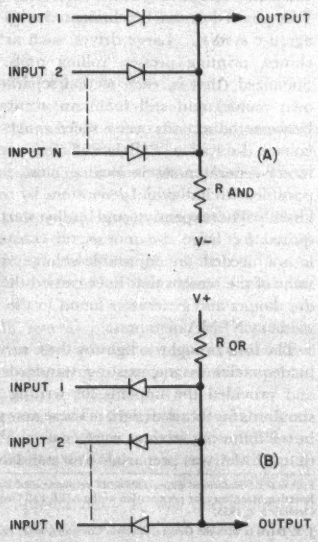

Fig. 1(A). Diode "and" gate working with negative pulses, and (B) diode "or" gate working with negative pulses

The considerations governing the design of any gate are the output requirements. If the device being fed by a gate is a transistor circuit, output current is the primary consideration. If one gate feeds another, the requirements are:

1. For an "and" gate feeding an "or" gate: that the "and" gate resistor, if completely cut off from its inputs, supply enough current to the "or" gate resistor to drive it negative, and to supply reverse currents for the other diodes in the "or" gate.
2. For an "or" gate feeding an "and" gate: that the "or" gate resistor, if completely cut off from its inputs, supply enough current to the "and" gate resistor to keep it positive, and to supply reverse currents for the other diodes in the "and" gate.

Using these requirements, design equations can be derived which include factors for the tolerance of resistors and the nonideal characteristics of diodes. Power-supply drifts can be handled by designing for the minimum supply voltage, and using capacitor coupling to the output devices (flip-flops, pulse amplifiers, or recording devices) being fed by a logic circuit.

Capacitor coupling from input devices to the logic circuits is not recommended. Transistor circuits can be directly coupled to logic circuits quite easily. A transistor circuit having characteristics closely approximating those of a switch is a good driving source for an "and" gate. The transistor switch must be pulsed to an open-circuit condition in order to represent a pulse to an "and" gate. If this switch acts as an input to an "or" gate, the switch must have a resistor-to-negative battery to drive the "or" gate negative when pulsed open. In most systems, more inputs go to "and" gates than to "or" gates.

The advantage of using multistage logic is the low cost of the gate circuits, an important factor for a computer with a complex logic system involving thousands of gates. Transistor switches are capable of driving multistage logic circuits. It is, therefore, felt that multistage logic circuits will come into use in the near future.

Digest of paper 55-431, "Engineering Multistage Diode Logic Circuits," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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New NEMA Standards for D-C Motors and Generators

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The author outlines the new NEMA suggested standards for d-c motors and generators. The changes described will result in a simplified standard which is realistic in terms of current requirements and practices. The reasoning behind these changes is discussed in detail.

RECENTLY the National Electrical Manufacturers' Association (NEMA) compiled a number of suggested standards for future design which pertain to d-c motors and generators.[1] These new standards concern what have been known as "general-purpose" integral-horsepower motors up to 200 hp and generators up to 150 kw. The nature of these new standards and their significant differences from the older standards make them of interest to all users, as well as manufacturers, of this type of equipment. It is the purpose of this article to describe these new standards and to tell how and why they were developed.

BACKGROUND

THE EARLIEST MOTORS in common use were d-c motors, and the first central stations and distribution systems were d-c. With the development of the induction motor and the transformer, a-c systems were installed and have gradually almost completely supplanted d-c systems for power generation and distribution. The d-c motor, however, has one prime advantage which no a-c motor has ever been able to match completely, and that is its ability to change speed over a wide range with easy adjustment. Consequently, d-c motors are still used in large quantities in many industrial applications with the user converting the a-c power he receives to d-c for supplying these motors. D-c generators are widely used to supply power to d-c motors and for other applications, such as plating, battery charging, etc. In spite of the almost universal use of a-c power systems, the number of d-c motors has been steadily increasing in recent years.

Studies made during the last two years by several of the member companies of NEMA showed that there had been a change in the way the majority of their d-c equipment was being applied. Formerly, the large industrial users of d-c motors had constant-potential d-c busses in their plants. Motor-generator sets of large size, or rotary converters supplied the factory distribution system. Many or all of the d-c motors in the plant operated from this bus at either constant speed or over a speed range by shunt field rheostatic control.

A survey made by the General Electric Company, for instance, showed that this condition no longer exists. On all recent applications of general-purpose d-c motors, this study showed that approximately 90 per cent were used on adjustable-voltage systems. Very few plants which still have a constant-voltage d-c bus are extending these systems or installing new ones. Of the motors used on constant-potential systems, approximately 80 per cent were adjustable-speed motors and 20 per cent were constant-speed motors. Therefore, less than 5 per cent of the recently purchased general-purpose d-c motors ran at a single speed. A large proportion of the adjustable-voltage drives had only one motor operating off the generator from which it received power.

This change in usage had come about for good reasons, mostly relating to the possibilities for improvements in drive performance which were being dictated by the trend of all industries toward higher output and better quality control. Much wider, essentially infinite, speed ranges are available with an adjustable-voltage system as compared with a maximum of 4-to-1 to 8-to-1 speed range possible on a constant-voltage system. Many drives require constant torque over a speed range, and the d-c motor operating from an adjustable-voltage source is best suited to supply this need. When a drive frequently starts, stops, or reverses, there is a large power loss during each accelerating and decelerating period in a system using a d-c motor on constant voltage or an a-c motor on constant frequency. This power loss can be eliminated with an adjustable-voltage d-c system. Large drives, such as paper-making machines, printing presses, rolling mills, etc., can be sectionalized (that is, each section separately powered by its own motor) and still maintain accurately related speed between the sections over a speed range with an adjustable-voltage d-c system. Higher efficiency is obtained when the motor-generator set is located close to the motor, as is possible with individual generators, by reducing distribution losses. The expensive and bulky starting equipment required for large d-c motors on constant-voltage systems is not needed on adjustable-voltage systems. These are some of the reasons that have caused the change in usage of d-c motors and generators found in the studies which were made by NEMA members.

The facts brought to light by these surveys showed certain inadequacies in the existing standards for d-c machines and provided the impetus for writing the new suggested standards for future design. These new standards described in the following sections were evolved about the same time that NEMA was preparing new standards for a-c integral-

Full text of conference paper CP55-727 recommended by the AIEE Committee on Rotating Machinery for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 3–7, 1955.

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horsepower induction motors. The rerating of the a-c motors was largely a result of improvements in the art of designing these motors and of the availability of new materials. Similar progress had been made in the art of designing d-c machines, and was another argument in favor of preparing new standards at this time.

INDUSTRIAL D-C MOTOR

A NEW DEFINITION has been adopted as a NEMA standard which reads: "An industrial direct-current motor is a direct-current dripproof motor having a continuous rating and designed, listed and offered in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of application."

One of the significant features of this definition is that it specifies the dripproof enclosure as compared with the "open" enclosure of the general-purpose motor definition. The surveys indicated that at least a dripproof enclosure was required in a high percentage of applications in order adequately to help protect d-c machines, particularly their commutators, when located in the average factory environment. The previous standards recognized dripproof d-c machines as an alternative with higher temperature rises than open machines and with no service factors applying to their ratings. Therefore, the new standards provide better protection while still retaining the service factor of the general-purpose motor.

This new definition was added to the standards in preferance to modifying the "general-purpose motor" definition partly because the old definition was still applicable to present-day a-c motors without change, and partly because it seemed desirable to imply in the title that these d-c motors were suitable for industrial use but not in the general-purpose sense that is associated with squirrel-cage induction motors. D-c motors are applied in industry for special purposes.

MOTOR VOLTAGE

THE STANDARD VOLTAGES for integral-horsepower d-c motors have been 115 and 230 volts. Since the standard d-c generator voltages were 125 and 250 volts, this allowed 10 and 20 volts, respectively, for line voltage drop. These were realistic values in the days of large d-c distribution systems where the motors and generators were frequently located a considerable distance apart. However, most drives today have individual motor-generator sets located near the d-c motor and the cable voltage drop is much less than these values. The General Electric Company survey showed also that in several plants which had constant-potential d-c systems, the average voltage at the motor terminals was 244 volts, with a maximum of 250 and a minimum of 226 volts.

Therefore, a suggested standard for future design has been added to the NEMA standards to rate d-c motors 120 and 240 volts. This reduces the allowance for line drop to 10 volts for the higher voltage systems, which is more than adequate for most applications. It was decided that it would be better to change the standard motor voltages rather than the generator voltages for two reasons. First, if a d-c motor rated 240 volts is applied on a 230-volt system, it will run slow, but can easily be speeded up by weakening the field. Second, new generators will have to operate in parallel with older 250-volt generators in certain instances and must be capable of continuously producing this voltage without overheating the fields.

The lower voltage of 120 volts is standard for motors only up to 10 hp (as most users prefer to go to higher voltage when applying larger ratings); 240 volts is standard for all motor ratings.

MOTOR HORSEPOWER AND SPEED RATINGS

THE NEMA STANDARDS for a number of years have recognized two types of d-c motors: constant speed and adjustable speed. Separate tables of hp and speed ratings for these two types were listed in the standards, and the hp ratings were each established on a different basis as to time and temperature rise.

The constant-speed motors were rated with very limited speed ranges by field control from a minimum of 1-to-1 to a maximum to 2-to-1. Ratings for these were established at each of the following base speeds: 100, 150, 200, 250, 300, 350, 400, 450, 500, 575, 690, 850, 1150, 1750, and 3500 rpm. These open motors were rated continuous, 40-C rise with Class *A* insulation and a 1.15 service factor. Motors with dripproof enclosure were rated 50 C, with no service factor.

The adjustable-speed motors had three tables of ratings for the three speed ranges of 3-to-1, 4-to-1, and 6-to-1 by field control with appropriate base speeds chosen from the foregoing list. Adjustable-speed motors had two hp ratings which were always two of the adjacent values in the following list: 1/2, 3/4, 1, 1 1/2, 2, 3, 5, 7 1/2, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, and 200. The lower hp rating for open motors was the continuous, 50-C rise rating at base speed with Class *A* insulation and no service factor, and also was the continuous, 40-C rise rating at 150 per cent base speed. The higher hp rating was the continuous, 40-C rise at 300 per-cent base speed and higher speeds. Between 150 and 300 per-cent base speed, the standards specified a linear increase in hp with speed between these two hp values. The rating of dripproof adjustable-speed motors was not covered by the standards. Totally enclosed fan-cooled adjustable-speed motors were rated on the same dual hp basis, where the lower value was a 1-hour, 55-C rating from base to 150-per-cent speed; at 150-per-cent speed it became the continuous, 55-C rating; at 300 per cent and higher speeds, the larger value was the continuous, 55-C rating; and between 150- and 300-per-cent speed the continuous, 55-C hp varied linearly with speed. This rather complicated rating system for adjustable-speed motors was an attempt to recognize the inherent increase in rating from a heating standpoint which is possible with increased speed. Unfortunately, the uneven steps between standard hp ratings, ranging from 20 to 67 per cent, does not, in all cases, represent a reasonable increase.

Table I shows the newly adopted suggested standard for future design listing 156 hp and speed ratings for 240-volt d-c motors. This compares with the four tables listing 502 different ratings which have been the standards for these

Table I. Horsepower and Speed Ratings for Industrial D-C Motors

A. The standard hp, base speeds, and speeds which may be obtained by field weakening for industrial d-c motors shall be as follows:

Hp at Base Speed (See Para. B)	Hp at 300 Per-Cent Base Speed and Higher Speeds	Base Speed—Rpm: 3500	2500	1750	1150	850	650	500	400	300	
		Speed by Field Control—Rpm									
1/4	0.65						3000	2600	2000	1600	120 and
3/4	1					3200	3000	2600	2000	1600	240 volts
1	1.3				3500	3200	2800	2600	2000	1600	
1 1/2	2		4000	4000	3500	3000	2800	2600	2000	1600	
2	2.6		4000	4000	3300	3000	2600	2600	2000	1600	1200
3	4		4000	3700	3300	2800	2600	2600	2000	1600	1200
5	6.5		3700	3700	3000	2800	2600	2400	2000	1600	1200
7 1/2	10		3500	3500	3000	2800	2600	2400	2000	1600	1200
10	13		3500	3500	3000	2800	2500	2200	2000	1600	1200
15	20		3500	3300	3000	2600	2500	2200	2000	1600	1200 240 volts
20	26		3500	3300	3000	2600	2400	2200	1800	1600	1200
25	33			3100	3000	2600	2400	2000	1800	1600	1200
30	40			3100	3000	2600	2400	2000	1800	1600	1200
40	52			3100	2700	2400	2200	2000	1800	1600	1200
50	65				2700	2400	2200	1800	1800	1600	1200
60	80				2400	2200	2000	1800	1600	1600	1200
75	100				2400	2200	2000	1800	1600	1600	1200
100	130				2200	2000	1800	1600	1600	1600	1200
125	165				2000	2000	1800	1600	1600	1600	1200
150	200				2000	2000	1800	1600	1600	1600	
200	260				1900	1800	1700	1600	1600		

B. Industrial d-c motors shall be capable of carrying a load equal to 1.15 times the base-speed hp rating when operating at base speed.
Industrial d-c motors shall be capable of carrying a load equal to 1.3 times the base-speed hp rating when operating at 150 per cent to 300 per cent of base speed.
When an industrial d-c motor is operating at the loading described in this paragraph, its operating characteristics, such as efficiency, temperature rise, etc., may differ from those specified when the motor is operating at the base-speed rating.

motors. The new standard does not classify the ratings as constant-speed and adjustable-speed, but groups them all together. The differentiation made previously was rather artificial inasmuch as the construction of the two types was very similar. It was felt that there was very little demand for constant-speed motors having a low base speed. Therefore, the standard motors with low base speed should be designed for adjustable-speed operation. Such motors will also be excellent motors for those few applications where little or no speed range is needed. A precedent had existed in the standards for the combination of constant- and adjustable-speed motors in the section pertaining to d-c motors larger than 200 hp, where ratings with low base speed were listed only as adjustable-speed motors. The new standard eliminates many duplications which existed in the old standards, such as 2 hp, 500 rpm base speed that had been listed four times with top speeds of 1,000 rpm (constant-speed), 1,500, 2,000 and 3,000 rpm (adjustable-speed). In Table I, any given hp and base-speed rating appears only once, in this case with a 2,000 rpm top speed. An attempt has been made to make the new top-speed ratings consistent with the inherent mechanical and electrical limitations of the various size motors when all are built of similar construction. Some of the old ratings required special construction to operate successfully at rated top speed; others did not utilize the full capabilities of the motor.

Because the speed range is not limited to the previous standard values of 3-to-1, 4-to-1, and 6-to-1, more choice in speed range is given in the new table than in the old, even with fewer total ratings. For instance, at 5 hp there are seven possible speed ranges listed as against a previous choice of four (considering the constant-speed ratings as one choice). The maximum speed range in the new table is 4-to-1. Although the old table showed ratings of 6-to-1 speed range, it was felt that motors of this range generally required special construction and their small usage did not warrant listing them as "industrial d-c" machines.

One new base-speed rating was added at 2,500 rpm. This fits in the previous large gap from 1,750 to 3,500 rpm. The surveys indicated there was little need for the base speed ratings of d-c motors to correspond to a-c induction motor speeds (only a few applications require interchangeability), so this was ignored in making the new table. The 575- and 690-rpm base speed ratings were combined in a new 650-rpm rating. Base-speed ratings of 100, 150, 200, 250, 350, and 450 rpm were dropped in the new table. It was felt that below 300 rpm the usage was so small as to take them out of the category of industrial motors. The other ratings dropped were intermediate to ratings retained and the steps between them were closer than necessary, considering the adjustability of d-c motor speed. The steps between adjacent base-speed ratings vary from 33 to 52 per cent, as compared with a variation of 11- to 100-per-cent steps in the old table.

All the motors listed in Table I have the continuous, 60-C rise, hp rating at base speed shown in the left-hand column. This rating, based on the use of Class *B* insulation, has a service factor of 1.15 at base speed. This provides extra leeway in the base-speed rating. Previously, open adjustable-

Table II. Power Required for Standard D-C Motors

D-C Motor, Hp	Assumed Motor Efficiency (Per Cent)	Required Kw	Proposed Kw
1/4	75	0.746	1/4
1	75	0.991	1
1 1/2	80	1.4	1 1/2
2	80	1.87	2
3	82.5	2.72	3
5	85	4.39	4 1/2
7 1/2	85	6.6	6 2/3
10	87.5	8.52	9
15	87.5	12.8	13
20	87.5	17.1	17
25	87.5	21.3	21
30	90	24.9	25
40	90	33.2	33
50	90	41.5	40
60	90	49.8	50
75	90	62.2	65
100	90	83	85
125	90	103.5	100
150	92.5	121	125
200	92.5	161	170

speed motors had no service factor at base speed, and neither constant- nor adjustable-speed motors had one when built with dripproof enclosure.

Comparative data of several manufacturers showed that when motors operated above base speed by field control, the thermal capabilities followed the curve shown in Fig. 1. The data showed that this curve was approximately right for most of the sizes and base-speed ratings under consideration. Accordingly, the new standard states that when operating between 150- and 300-per-cent base speed, the service factor shall be 1.30. For 300 per cent and higher speeds (where the rating includes a speed range that wide) a new horsepower rating is established which is also a continuous 60-C rise rating. These are listed in the right-hand column of Table I, and are approximately 1.3 times the base-speed values. This new system has some advantages over the old tapered rating system. Ratings are established at only one temperature-rise value. The high-speed ratings are more nearly consistent with the inherent heating characteristics of the motors, and do not require designing each machine to meet an artificially established value.

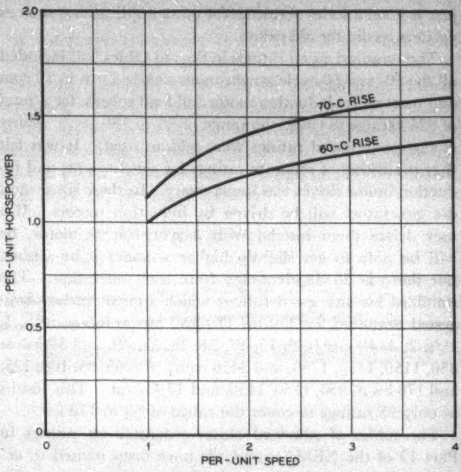

Fig. 1. Variation in permissible output with speed of industrial d-c motors when speed is changed by field control

GENERATOR KW AND SPEED RATINGS

A FRESH CONCEPT was used in establishing the new table of standard d-c generator ratings. The old tables had listed standard ratings of ¾, 1, 1½, 2, 3, 5, 7½, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, and 200 kw. These are the same numbers as used in the motor-horsepower tables, and had been arbitrarily chosen as a reasonable series without consideration of their most popular modern usage. This is, according to the surveys, supplying power for adjustable voltage d-c motor drives, usually a single motor. With this idea in mind, the power necessary to supply the standard d-c motor ratings was calculated as shown in Table II using typical values of motor efficiency. Looking at the problem from another angle, the output available from standard a-c motors using typical generator efficiencies was calculated as shown in Table III. The values chosen were a compromise between theoretical values obtained by these two methods and, fortunately, satisfy both conditions quite well. The 1.15 service factor of both the a-c motor and the d-c generator can take care of any of the small mismatches. The major advantage of this method of rating d-c generators is shown in Table IV where both the old and new motor-generator set ratings are given for single d-c motor drives of standard hp. In 13 of the 20 cases the generator rating is less than it used to be, and in 11 of the 20 drives the a-c motor has been changed to the next smaller rating. The old values had been chosen as the nearest larger standard generator rating required by the d-c motor and the nearest larger a-c motor to supply the full nameplate rating of the generator. Thus, there had been a considerable penalty imposed on these drives by the standard kw ratings of d-c generators. The odd-sounding kw values in the suggested standard for future design have real merit for this type of application, and will provide

Table III. Power Available from Standard A-C Motors

A-C Motor, Hp	Assumed Generator Efficiency (Per Cent)	Theoretical Kw	Proposed Kw
1½	75	0.84	¾
2	77.5	1.15	1
3	82.5	1.85	1½, 2
5	85	3.18	3
7½	85	4.76	4½
10	87.5	6.53	6½
15	87.5	9.8	9
20	87.5	13.1	13
25	87.5	16.3	17
30	90	20.2	21
40	90	26.9	25
50	90	33.6	33
60	90	40.3	40
75	90	50.3	50
100	90	67.2	65
125	92.5	86.4	85
150	92.5	103.5	100
200	92.5	138	125
250	92.5	173	170

Table IV. Motor-Generator Sets for Single D-C Motor Drives

D-C Motor, Hp	D-C Generator, Kw		A-C Motor, Hp	
	Present	Proposed	Present	Proposed
¾	¾		1½	
1	1		2	
1½	1½		3	
2	2		3	
3	3		5	
5	5	4½	7½	
7½	7½	6½	15	10
10	10	9	15	
15	15	13	25	20
20	20	17	30	25
25	25	21	40	30
30	30	25	50	40
40	40	33½	60	50
50	50	40	75	60
60	60	50	100	75
75	75	65	125	100
100	100	85	150	125
125	100		150	
150	125		200	
200	200	170	300	250

just as good a series of ratings for other applications, such as exciters, as did the old values.

The standard speed ratings in the old tables had included all the 50- and 60-cycle synchronous speeds down to 75 rpm and most of the induction motor full load speeds, for a total of 825 ratings to cover the range of ¾ to 150 kw. Many of the lower speed ratings were seldom used. It was felt that the listing of separate ratings for synchronous and induction motor drives was unnecessary. In these sizes, most d-c generators will be driven by induction motors. If a user drives them instead with a synchronous motor, he will be able to get slightly higher voltages if he wishes, but there is no disadvantage from such operation. The standard kw and speed ratings which appear in the "Suggested Standard for Future Design" are as follows: ¾, 1, 1½, 2, 3, 4½, 6½, 9, 13, 17, 21, 25, 33, 40, and 50 kw at 850, 1150, 1450, 1750, and 3450 rpm; also 65, 85, 100, 125, and 170 kw at 850, 1150, 1450, and 1750 rpm. This results in only 95 ratings to cover the range of ¾ to 170 kw.

The tables of standard motor-generator set ratings in Part 13 of the NEMA standards have been revised in accordance with these changes in d-c generator ratings.

INSULATION AND TEMPERATURE RISE

Perhaps the part of the new standards of most general interest is that which establishes Class *B* insulation with a temperature rise of 60 C for the industrial (dripproof) motors and generators. The previous NEMA standards had long recognized Class *B* as one of the acceptable groups of insulating materials and had shown the usual temperature rise values to be used with it the same as ASA, AIEE, and other standards. These temperature values of 70 C for open machines and 75 C for totally enclosed machines did not provide for any service factor. The definition of a general-purpose motor describes it as Class *A* insulated, with a 40-C temperature rise. Thus, this new step represents a sharp break with tradition for this type of equipment and a divergence from the present practice of the sister line of general-purpose a-c induction motors.

The chief argument in favor of using Class *B* insulation and a higher temperature rise is that it results in a smaller machine. This means that less space need be provided for a given rating, the machine will weigh less, the inertia of the armature (Wk^2) will be less, and the response faster. These last two points are especially important, for many applications of d-c motors require frequent and rapid starts, stops, reversals, and changes of speed. All of these factors are important to the user, as is the fact that a reduction in the amount of material helps the manufacturers meet the problems of ever-increasing costs of material and labor. Sufficient progress in the art of designing d-c machines has been made that reduction in size can be made without sacrifice of commutating ability.

Considerable development work has been done recently on Class *B* materials which encouraged the NEMA D-C Motor and Generator Subcommittee to choose this class. Of particular interest is the development of wire enamels capable of operating at Class *B* temperatures. This holds much promise of further reducing the size of machines below that required with glass- or asbestos-covered wire.

The choice of 60-C rise for these new Class *B* machines was based on the revision currently being made in Table I of the ASA Standard C50.[2] The ASA table shows this value to be used for "general purpose and other generators and motors having a 1.15 service factor." This service factor has been a part of the rating of general-purpose motors for many years and is intended to compensate for the fact that the exact service conditions to which such motors are subjected are uncontrolled and not easily determined. This is perhaps not so true in the case of d-c motors as in a-c induction motors, but there is another good reason for having a service factor at rated speed for d-c motors. As mentioned, most d-c motors today are applied on adjustable-voltage systems and, therefore, will operate during a part of the duty cycle below base speed. Self-ventilated motors will tend to run hotter at lower speeds because of the reduced amount of cooling air. The service factor, then can be useful in providing a safety margin for operation below base speed.

Several companies tried to survey their markets to determine the acceptability of Class *B* insulated machines rated at higher temperatures. This was a difficult thing to measure, and there were conflicting reports even on individual surveys. But, in general, the consensus of opinion seemed to be that Class *B* insulation as such was as acceptable to motor users as Class *A* insulation. In fact, many customers today pay a premium to obtain machines with Class *B* insulation. One of the chief concerns about higher temperature rating seemed to be that maintenance personnel would not be familiar with machines capable of operating at these temperatures and would be inclined to think a machine was overloaded when using the "feel" test on the outside of the frame. Customers were also afraid that the frame temperature might be high enough to cause burns. However, neither of these factors seem to pose much of a problem since the increase of frame temperature will be small compared with the increase of the winding temperatures. In fact, with improved ventilation, the frame temperature may be no higher than on present Class *A*, 40-C machines. Class *B* insulation at even higher temperatures has been standard for many years in the land transportation industry[3] and for steel mill auxiliary motors.[4] Both of these applications are extremely heavy duty, yet Class *B* insulation has proved to be very reliable. There seems also to be a trend for foreign manufacturers to go to higher temperature ratings.

Totally enclosed machines in this new line will be rated continuous 75-C rise in accordance with existing standards. Previously, the NEMA standards for adjustable-speed totally enclosed motors provided only a 1-hour rating at base speed, which has been a severe limitation for many applications.

FRAME ASSIGNMENTS

The NEMA standards have frame assignments for most a-c induction motor ratings. Previously, there were frame assignments for d-c motors for the smaller frame sizes. However, before this program of major revisions to the standards was undertaken, the frame-assignments for d-c motors were rescinded. The possibility of making new

frame assignments in line with the other new standards was considered by the committee. However, it was felt that there was very little need for such standardization and, therefore, no frame assignments for the new ratings are contemplated at present.

PERFORMANCE CHARACTERISTICS

As a result of the changes in rating methods and the higher temperature rise, certain revisions in the standards pertaining to performance characteristics are being made. These have not been completed at this writing but do not appear to be seriously different from the old standards. There will be a larger change in the full-load speed of motors (and voltage of generators) during the warming-up period. Most of the other changes, however, are only modifications to suit the new rating methods.

SUMMARY

A complete revamping of the NEMA standards pertaining to d-c motors and generators has been made to bring these standards in line with the modern usage of these machines. The new suggested standards for future design should enable manufacturers of industrial d-c motors and generators to make smaller, lighter, and faster-responding machines with a much higher degree of standardization than under the previous standards.

REFERENCES

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3. American Standard for Rotating Electrical Machinery on Railway Locomotives and Rail Cars and Trolley, Gasoline-Electric, and Oil-Electric Coaches. AIEE No. 11 1943.
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Broad Survey of Engineering Profession Essential

S. C. HOLLISTER

The author outlines some of the pressing technological problems facing the world and the responsibilities which they impose on the engineering profession. Recommendations for a thorough appraisal by the Engineers' Council for Professional Development are proposed.

THERE IS NO DOUBT that during the past quarter century the tempo of the whole world has increased to an astonishing degree. Through developments in engineering, our communications and transportation systems have shrunk the world so that now it is practically only a fraction of the size it used to be. Because of this tremendous change in communications and transportation, the world political arena has been completely altered, and mass attitudes are being built up or broken down.

THE ENGINEER'S ROLE

The engineer is at the core of this development. He has created many of the technical means which have brought about this change and, in many instances, has participated in the direction of its development. To an increasing degree he is becoming a practicing sociologist, an active economist, a political planner; all in addition to his function as one who interprets scientific principles into useful works.

Although human and international relationships have been shifting at a remarkable rate—a shift in which the engineer's work has been an active ingredient—the very basis of his technical accomplishments, namely, the fund of scientific knowledge, also has been enormously expanded in this period of time. One can only partially visualize the tremendous ramifications of this new knowledge and the extent to which it may be applied to human service. The public has become aware that the engineering profession's many accomplishments have a bearing on our daily life; accomplishments that bring men closer together, that unify their problems and common concerns, that lighten their burdens and extend their capacities, and that enhance the common welfare.

Engineers have accomplished so much that now it is taken for granted that what they produce will function without difficulty. It is further taken for granted that they will safeguard the life and property of the public. Nobody stops before a bridge to make computations to see whether or not he should cross the bridge. There is still another public assumption that puts a tremendous responsibility upon the engineer. He has worked so many miracles in the eyes of the public that it is now assumed that he will bail mankind out of any crisis that may arise. Take for example our present headlong dash toward consuming our natural resources. If the question is raised that perhaps

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we should be more cautious we are told at once that when the pinch comes they will find something else that probably will be better—"they," in this case, meaning the engineer.

It is easy to see, therefore, that the engineer has assumed in the mind of the community a professional status. As a group, engineers have become a definite entity in the public mind both as to function and accomplishment. This is his status regardless of the arrangements of his employment. The services which engineers are being called upon to render are increasing, not uniformly with time, but actually exponentially. We know that there are many things on the shelf waiting to be worked upon. We know that new knowledge, useful for the engineer, has been increasing at a tremendous rate. We know also that even with the normal development of former lines of engineering, new avenues of approach are opening in many directions.

There is much evidence to show that only a certain proportion of our population has the necessary qualifications to undertake the engineering profession. Many of the qualifications are similar to those required for success in other lines. Out of a given age group, for example, out of the number of boys reaching age 18 in a given year, only about 17 per cent have the necessary intellectual capacity to undertake work in our profession. This same 17 per cent, however, must also supply the talent for such other professions as law, medicine, and science. They must also supply the top-level people in the crafts, including the better chefs, cabinet makers, glass blowers, tool makers and the like. The interplay of interests and degree of enterprise or of fortitude will have a bearing upon which field the boy enters. Several years ago I pointed out that only about 47,000, amounting to 1/4 of the 17 per cent I spoke of, could be expected to enter the engineering profession at the freshman level. We have, through the beating of drums and the shaking of bushes, gone higher than this number. A study of performance in college, however, points out that it is quite apparent that after we passed approximately 47,000, the mortality rate took a sharp increase. In other words, it would seem we are dipping a little further into the supply and reaching a little below the likely level of capacities.

In speaking of this matter of intelligence, the capacity for receiving a certain kind of education, etc., it must be borne in mind that we are doing so in the light of our educational methods, our guidance systems, and the manner in which we communicate to the oncoming youth the possibilities and attractiveness of the various professions and other occupations which he might conceivably be capable of entering. We need to make improvement in all of these methods of communicating with the youth and we need improvement all along the line in educational operations. These, however, are not going to be changed suddenly. It will be a long process of evolution if we are to make any changes at all, but we must continually try.

THE PROBLEM

Returning now to the meaning of our experience in the success or failure of boys attracted to the engineering profession, it is apparent that we have reached a fixed percentage of the population that will enter engineering. When we look again at the services that engineers are being called upon to perform and the fact that these service needs are increasing at an accelerating rate, we see that the demand for services is outrunning the rate of supply of people to perform them. This does not necessarily mean that we have to go without such services, at least not for the present. It does mean, however, that the pattern of utilization of engineers must be modified considerably. We know that in many fields the beginning engineer soon progresses to paper work and from there to administrative duties and frequently to less and less engineering contribution. The pattern of advancement is often in lines other than engineering. It is necessary to modify this state of affairs so that the path and the rewards lie closer to engineering practices. In this respect, we can take a leaf out of the book of the medical profession where the number of doctors is about half the number of engineers in the population. Any doctor performs as the nucleus of competent but less trained people, and in such a way the ability of the doctor is proliferated over a wider contact area. To some degree the legal profession is organized along similar lines. The engineering profession, if it is to render the services that we know are ahead of it, must be considerably overhauled both in the manner of utilization and in the pattern of preparation of such a career.

There already are signs of threats to the profession that should motivate us to give heed soon to a re-evaluation of our professional activities. On the one hand, scientists are entering the field, in many cases with telling effect. They have better fundamental training and, for the most part, they are able to stay in the professional field without shift to administrative function. At the other end of professional activity we are feeling the effects of unionization in areas where large numbers of young engineers may be used in more or less standardized and routine functions. We have become, in part of the profession at least, slaves to job classification rather than men working toward the utilization of individual talents in their highest form.

NEEDS FOR APPRAISAL

I have made a number of statements here as to my impressions of the situation in the profession. Most of them are qualitative. Many of them are in some degree controversial. What is lacking in this critical situation is an accurate, carefully made appraisal of both utilization and supply. Suppose, for example, we have a scientific sampling of each school of engineering and we follow the progress of each graduate in the sample. If we did this for different classes of graduates, we would amass a body of material that would give us a consolidated picture of the training, development, growth, utilization, and accomplishment of the individuals in the profession. We would then be able to note with some assurance the factors to which we could most profitably give attention.

This is not all the looking that we need to do. We need to make some estimate of the oncoming problems the engineers are most assuredly going to be called upon to solve. We need a careful estimate of the new frontiers and some notion of when we are going to be called to enter upon them. Some of these frontiers are in urgent need of development, and

will render great benefits and profit to the community. The need for developing any of them stems from the fact that some of our material resources are becoming exhausted, and many other important ones threaten short supply. We need a study pointed toward improvement of the supply of our necessary manpower. We need studies of possible patterns of utilization; in short, we need some objectives defined in terms of the responsibilities the community has placed upon us. It is clear, or so it seems to me, that the profession is badly in need of a comprehensive survey having as its objective the evaluation and appraisal of its present and likely future adequacy and an appraisal of the areas in which action must be taken to effect improvements.

This council asked in 1952 for an appraisal of the preparation of engineers and referred the matter to the American Society for Engineering Education. That Society has completed such a study and during the current year has published its report. It is a useful and important study and if implemented will, I am sure, contribute to the progress of the profession. But at the same time one is impressed with the fact that it deals with but one facet of a very much larger problem, a problem that the educators may see but can do nothing about.

A notable study was made of the medical profession about 40 years ago which culminated in the famous Flexner Report. This report has had a profound effect upon the development of the medical profession and has strengthened the effectiveness of that profession in its services to the community. In consequence, it has contributed greatly to the stature of the medical profession in the eyes of the community. More recently, a similar study has been undertaken in the legal profession. It is too early to mark the results but undoubtedly similar benefits will derive from it.

It would seem clear that everybody stands to gain by a well-executed study of this sort. First of all, the community would be served by any improvement that could be brought about in the functioning of our important profession. Those immediately concerned with function, namely the employers of engineers and the engineers themselves, would profit both individually and collectively by such a well-designed and well-executed survey. And finally, such a survey should lay the groundwork for improvement and better definition of the engineering profession as a whole.

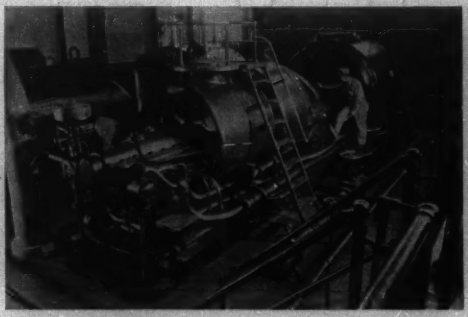
Who should sponsor such an undertaking as this? It has been suggested that each of the professional branches should undertake a study of its own. One only needs to recall the interweaving of the services of the separate branches, the extent to which they have a relatively common background, the fact that in many cases their talents and efforts impinge upon the same general problems, and the fact that many, trained in one branch, actually serve through their professional lives in another branch, to realize that there would be duplication, waste of effort, waste of money, and in general, unnecessary confusion if the study were to be made in that manner. Furthermore, it seems to me that such a study needs background that can be obtained only through the guidance of an organization whose principal objective is the development of the engineering profession in all aspects. Clearly then, the sponsor for such an operation should be the Engineers' Council for Professional Development.

What is needed to accomplish such a survey? It would seem appropriate to set up an advisory board from the engineering profession to give guidance to the inquiry itself. This board should represent the various branches of engineering. It should represent different elements of the structure of the profession and different ways in which these elements function. It should be as small and compact as possible. It should report to this Council. Under such a board should be organized a competent full-time staff to conduct the survey. It should be headed by a full-time director. It should be staffed with specialists appropriate to the different lines of inquiry.

It would be essential that the operation be adequately financed, since it is conceivable that the cost of such a survey would in the end amount to as much as a million dollars. There seems no question, however, that the benefits to be derived by the community are so great that such a sum becomes unimportant in proportion to the benefits.

Power Company Retires Veteran Turbine

Retired after 47 years of service by the Virginia Electric and Power Company, Richmond, Va., is this pioneer 3,250-kw steam-turbine generator built by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. In 1903, it was significant as the highest rated 1,800-rpm machine in the United States. The unit, dubbed the "General Lee" by its operators, has delivered up to 5,500 kw for several hours on peak evening-load duty for many years. When inspected three years ago, the unit was found to be in good operating condition, as it was at the time of its retirement. Maintenance costs on the machine over the years have been extremely low, with replacements over the entire 47 years of service listed on one half of a repair index card.



National Bureau of Standards Preferred Circuits Program

J. H. MUNCY

The concept of standardization, which has been successful in the field of basic electronic components, is being extended to cover electronic circuits. Steps which have been taken in this direction by the National Bureau of Standards are described.

MANY FORMS OF STANDARDIZATION have been practiced within the electrical and electronics industry, with considerable profit both to the consumer and manufacturer. An example is the adoption of National Electrical Manufacturers Association Standards for Electric Motors and Generators. The purpose of this paper is to point out the need for a form of standardization that is somewhat peculiar to the electronics industry and particularly to the military equipment manufacturer. This need is the standardization of circuit configuration and electrical values. The wide latitude in choosing parts and configuration within which the electronic designer may work can be seen by recalling the resistance-coupled amplifier tables as given in the tube manuals. Many combinations may be used even in volume production because of the ease with which conventional pigtail components are soldered into place. As the electronics manufacturer converts to mechanized production, it becomes much more expensive to make changes of component value and circuit configuration.

THE STANDARDIZATION PROGRAM

A PROGRAM has been undertaken by the National Bureau of Standards to assist industry in the standardization of electronic circuits. This program is under the sponsorship of the Industrial Planning Division, Bureau of Aeronautics, Department of the Navy, and is limited to Bureau of Aeronautics equipment; but the concept is applicable to many other areas within the electronics industry.

Ideally, all military electronic equipment would be constructed with completely interchangeable subassemblies for a large percentage of circuit functions. Certainly, a great deal more can be done than heretofore toward attainment of this goal. However, certain deterrents are recognized: for extremely lightweight, compact, high performance designs, the concept of interequipment standard subassemblies seems to entail too high a penalty; also, manufacturers employ individual construction and assembly practices that make such physical standardization prohibitively slow.

The existent problem may be more fully comprehended by examining circuits in use that perform identical functions. There are, for instance, at least eight distance-mark generator examples, four of which are shown in Figs. 1 through 4. These are taken from equipment in current use except for Fig. 1, which is taken from a 1943 design. The applications differ only in the spacing of the marks. The spacing is controlled by the values of the inductance, capacitance, and resistance in the cathode circuit of the second tube. These components are usually switched, as several spacings are frequently required. These inputs are all derived from display gate generators and the outputs are utilized identically in display video systems. Each example consists of switch tube, Hartley oscillator, shaping stage, and a blocking oscillator. The major differences are the shaping

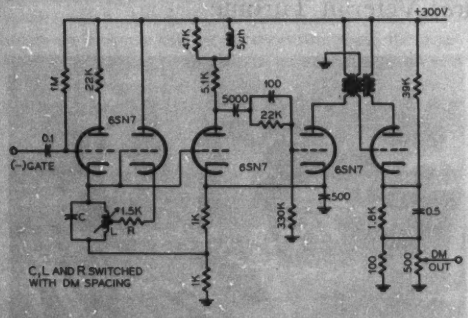


Fig. 1. Distance-mark generator using multivibrator-shaper, biased-cathode blocking oscillator

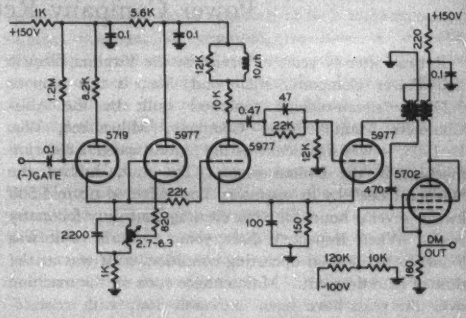


Fig. 2. Distance-mark generator using multivibrator shaper

stage and the biasing of the blocking oscillator. The first two examples use a modified multivibrator while the others use variants of squaring amplifiers with differentiation. The multivibrator examples have much better zero-delay characteristics than the amplifier examples. The design used in Fig. 1 could have been adapted for all these applications even though miniaturization required the successive employment of miniature and subminiature tubes. The preferred circuit, shown in Fig. 5, was derived to cover the full range of performance required of all the examples.

The choice of supply voltage is an aspect of design that greatly affects circuit standardization. Supply voltages of 300, 150, −150, and −300 seem to be logical choices, inasmuch as a study showed that they are the most commonly used in current practice.

The reasons may not be apparent to all why many similar models of military electronics systems which differ only slightly in design are developed and put in use, while commercial systems of comparable complexity are usually retained relatively unchanged for many years. The paramount factor is, of course, the urgency of incorporating newly developed electronic devices that affect only a small portion of a system. Such a device might be a tunable magnetron in an airborne search radar. The modulator, local oscillator, and radio frequency sections would require redesign while the receiver, indicator, and synchronizer might well remain functionally identical. Another factor is changing operational requirements. A new communications set may be required to increase the number of channels within the same band. The factor of changing aircraft or vehicle configuration is always present. A new system may represent only a repackaging and miniaturization of the older system with very slight or no changes in system parameters. If one development activity or engineering laboratory were solely responsible for all similar equipments, such changes might normally be made without extending beyond the parts necessarily affected. But where, as often happens, the design of the revised equipment falls to a different group or organization, extensive changes in the supposedly unaffected parts of the system are often made. There is, of course, no way to insure this continuity of design effort. New suppliers may be successful in bidding. Also, within one company there is not necessarily a continuity. Changing workloads and company growth have frequently necessitated the assignment of the problems to different groups of engineers.

The National Bureau of Standards' program was initiated with a feasibility study to determine the degree of similarity of individual electronic assemblies. Surprisingly, it was found that a great deal of agreement has been reached because of reasons of design efficiency. Among the characteristics considered were bandwidths, interconnecting amplitude levels, pulse rates and rise times, and impedance levels. By study of a number of systems that represent the largest procurement dollar volume, it was estimated that from 50 to 70 per cent of like systems are capable of circuit standardization. This estimate was based on the number

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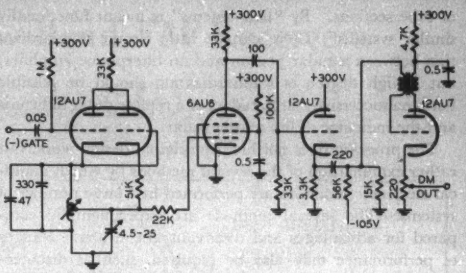


Fig. 3. Distance-mark generator using pentode-amplifier shaper, series-triggered blocking oscillator

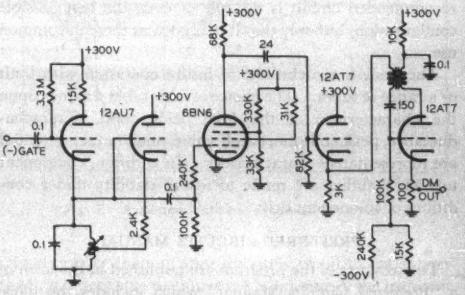


Fig. 4. Distance-mark generator using gated beam-amplifier shaper, series-triggered blocking oscillator

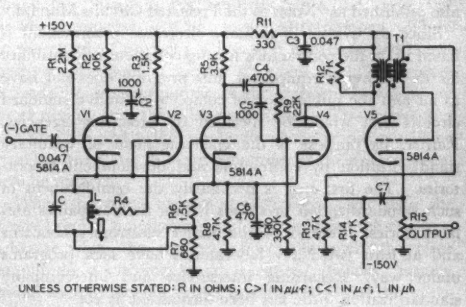


Fig. 5. Distance-mark generator, National Bureau of Standards Preferred Circuit No. 55

The distance-mark generator is used to generate accurately spaced pulses which are mixed into the video amplifier chain to indicate the range of radar echo pulses.

Distance-mark spacing:	*1 to 25 miles*[1]
Input gate amplitude:	*60 to 210 volts, negative*[2]
Input gate pulse repetition frequency:	*200 to 2,000 pulses per second*
Delay (input gate to marker):	*0.1 to 0.2 microsecond*
Marker amplitude:	*30 volts (R15 = 220 ohms)*[3]

All resistances ±10 per cent, except R2, R11, ±20 per cent

Notes:

1. *L, C, and R4 determined by distance-mark spacing selected.*
2. *Input gate from Preferred Circuit No. 41 used in tests.*
3. *For complete characteristics of blocking ovcillator, see Preferred Circuit No. 47*

of tube sections. By "like systems" is meant functionally similar systems. There can be little circuit standardization between a radar beacon and an interphone amplifier, but a high degree of standardization should be possible between successive search radars or a remote radar indicator and the indicator of the master radar.

The program does not involve original design work, but rather examination of the several methods by which identical electronic functions are performed in a large number of systems. The several methods are experimentally compared for advantages and disadvantages, if any. Ranges of performance may also be required, such as distance-mark spacing. The preferred circuit is usually taken from one of these designs with the performance variations allowed by component change. It cannot be contended that the recommended circuit is the sole or even the best possible configuration, but only that it is as good as those in common use.

The designs are checked to insure operation with limit or a range of tubes. The choice of limit tubes depends upon the characteristic of the tube being used. Transconductance, peak emission, cutoff valve, and contact potential are representative characteristics. In addition, component tolerance studies are made to insure stability under conditions of component drift.

PREFERRED-CIRCUITS MANUAL

THE RESULTS of the program are published in the form of a "Preferred Circuits Manual" which includes the more frequently encountered circuits.* A summary of the many variations from which the preferred circuit is derived is also published as "Notes to the Preferred Circuits Manual."

Since the system of military electronic procurement is based upon the contractor's having complete responsibility for the delivered equipment, this program does not have as an aim the publication of complete definitive standard circuits that would be specified by procuring agencies. Rather, its purpose is the encouragement of voluntary standardization by contractors and development laboratories. The first step is necessarily the establishment of such standardization programs within the companies and laboratories. Several of the larger electronics concerns and at least two Navy laboratories have such programs under way. Regarding interservice and intercompany standardization, little has been formalized as yet.

First drafts of the preferred circuits manuals were circulated in September 1954 to a large segment of the electronics industry for comment and suggestions. The response was extensive and, in general, favorable. Advantages which appealed to the industry included the prospect of greater reliability of the more routine portions of over-all designs, reduction of design man-hours on the assistant and junior engineering and drafting levels, and important savings in the precious supervisory time of senior personnel.

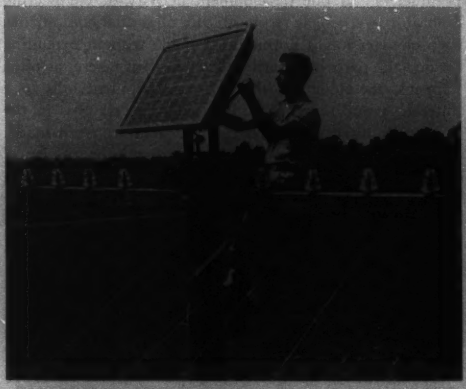
ADVANTAGES

THE ADVANTAGES of a circuit standardization program will depend upon the activity. For the equipment developer, the most important advantage at this time probably is the economy of engineering manpower. Not only will development time be saved, but also production costs will be lowered greatly when and if designers are able to utilize identical mechanical subassemblies. Some economy would result if the number of component values were decreased and if portions of production drawings were usable on several production runs. For the military services the advantages are primarily lowered procurement cost and maintenance economy. The logistics of supply will be simplified, but the chief economy will be in maintenance training and maintenance time. Inasmuch as repair crews are usually responsible for several similar equipments, it would expedite their efforts to work with familiar circuits.

From the concept of reliability there are other eventual advantages. It should be possible to establish good design practices or at least a higher level of quality for designs. The new or inexperienced engineer will be able to evaluate his designs easily against older well-proved designs. Fewer design mistakes would reach production. Since the design engineer will be freed from originating completely new circuits, he can concentrate on the execution of the design and upon the novel and untried portions of his development.

* To be available as NAVAER 16-1-519 from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Solar Battery Field Experiments



The 432-cell Bell Solar Battery is being used in experiments near Americus, Ga., 135 miles south of Atlanta, for developing more and better rural telephone service. The above photograph shows a Southern Bell Telephone Company cable repairman adjusting the device in order to pick up the prevailing light. Silicon disks, each about the size of a quarter and extremely sensitive to light, are capable of delivering power at the rate of 100 watts per yard of effective surface. The solar battery, announced last year, is an invention of the Bell Telephone Laboratories.

Impulse Noise in Narrow-Band FM Receivers

S. P. LAPIN
ASSOCIATE MEMBER AIEE

J. J. SURAN
ASSOCIATE MEMBER AIEE

THE RELATIVELY NARROW BAND FM communication receivers designed for use in mobile equipment are subject to disturbances caused by ignition systems in automobiles as well as to other disturbances of a similar transient nature. R-f signals are radiated from such ignition systems and these noise signals combine with the desired carrier to produce impulse-noise interference. When the disturbances are of a magnitude considerably greater than the desired information signal, and assuming that the receiver operates in accordance with the theoretical principles of frequency modulation, the receiver will respond only to the transient noise signal for the duration of the noise impulses. This results in receiver "blanking." If the disturbing signal is of approximately the same amplitude as the desired signal, the two signals combine in the receiver to produce sudden changes in phase. These sudden phase variations result in large frequency excursions at the discriminator and cause shock excitation of the audio section of the receiver. Thus, when the interfering signal is either greater than or approximately equal to the amplitude of the desired signal, information will be lost. It is, therefore, desirable to design the frequency-selective elements in such a manner as to minimize this type of interference.

There is a unique relationship between the transient response and the frequency response of the selective circuits in the receiver. The particular way in which the selectivity is obtained makes no difference in this relationship as long as only minimum-phase shift networks are considered. The transient response for the usual selective circuit employed in FM communication receivers takes the form of a damped, sine-wave modulated r-f carrier. A mathematical function, derived empirically, which closely approximates the transient obtained experimentally is given by

$$e_0(t) = Kt^n \epsilon^{-\alpha t} \sin \omega_c t \frac{\sin^m (\omega_b t + \theta)}{(t-D)^m} \qquad (1)$$

In equation 1, ω_c corresponds to the center frequency of the band-pass and is approximately equal to the frequency of the desired carrier, ω_b relates to the bandwidth of the channel ($BW \approx 2\omega_b$), the exponential argument α is a damping constant of the selective networks, D may be considered a delay term which is inversely related to the bandwidth ($D \approx 2\pi/BW$), and the other constants are determined by the number and effective "Q" of the particular selective circuits. An illustration of the wave form given by equation 1 is shown in Fig. 1.

Since information will be disturbed as long as the transient is greater than or approximately equal to the carrier signal, it is desirable to reduce the amplitude of the transient as quickly as possible. It has been determined that if the frequency response of the selective circuits is such as to round the "nose" of the bandpass curve, the "ring," or transient response, will be more greatly damped. Thus, in the transient response of Fig. 1, a more rounded bandpass would result in greater damping after 210 microseconds, i.e., the amplitude of the transient would decay more rapidly after the initial maximum. This means that the time for which the amplitude of the transient will be equal to or greater than the amplitude of the desired signal will be reduced.

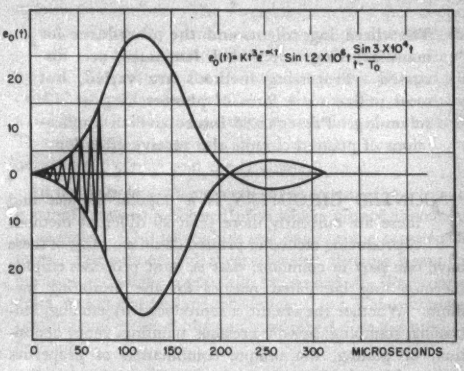


Fig. 1. Assumed transient response for n = 3

When the transients are considerably larger than the desired signal, a popping sound is heard from the receiver, whereas when the two are of approximately the same amplitude, a clicking sound is heard. "Clicks" usually sound more annoying to the listener, but when the transmission of intelligence is considered of prime importance, it is found that "pops," which interfere with the signal for a longer period of time, are more disturbing to the information content of the transmitted signal.

Field tests have indicated that FM receivers having filters with a higher degree of attenuation for the transient, i.e., filters with rounded "noses," are subject to less interference from impulse noise than receivers having filters of a flat-type bandpass response curve.

Any compensation made in the selective networks of a receiver to reduce impulse noise must, of course, take into account other types of disturbances such as random background, or "white," noise and the possibility of interference from adjacent channels. The information capacity of the channel, in the presence of all probable sources of noise, must ultimately be optimized for the best results.

Digest of paper 55-429, "Impulse Noise in Narrow-Band FM Receivers," recommended by the AIEE Radio Communications Systems Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27-July 1, 1955. Published in AIEE *Communication and Electronics*, September 1955, pp. 450-4.

S. P. Lapin is with Motorola, Inc., Chicago, Ill., and J. J. Suran is with the General Electric Company, Syracuse, N. Y.

Laminates for Printed Circuits

N. A. SKOW

The three ingredients and the procedures for manufacturing metal-clad laminates are discussed. Processing methods are varied, but most utilize some form of photoetching or silk screening. Present and future civilian applications of printed circuits also receive attention.

PRINTED CIRCUITRY is a popular subject and there are currently more than 20 different methods of producing etched or printed circuits. Most of these have one part in common; that is, most processes employ thermosetting laminated plastics for the insulating medium. Whether the circuit is reproduced by etching, embossing, stamping, powder pressing, painting, vapor deposition, or plating, the unique combination of properties possessed by plastic laminates has made a major contribution to this important electronics development.

Reduced to simple terms, printed circuitry is merely a method of wiring electronic circuits without the usual tedious hand labor. Its use permits the manufacturer of electric or electronic equipment to produce a large number of units in a limited space, to eliminate assembly errors, to reduce the amount of testing required by conventional methods, to miniaturize equipment, and to provide relatively inexpensive plug-in components which will reduce cost while providing the consumer with a better product. As important as these objectives are, they are not the main reason behind the electronics industry's intense interest in etched wiring. The real interest is that printed circuits will pave the way to complete standardization of electronics parts and complete mechanization of assembly. Millions of dollars have already been spent on standardizing components, so mechanized production or automation will soon be more than an industrial dream.

The base for the metal-clad laminate may be any one of a dozen or more varieties. It might be paper, cotton fabric, glass fabric, or orlon fabric bonded with phenolic, melamine, dialphthalate resins, epoxy, silicone, or polyester resin. The base most commonly used, however, is Military Grade *PBE-P*, which is National Electrical Manufacturers Association and American Society for Testing Materials Grade *XXXP*. It is made from an absorbent paper bonded with a phenolic resin which is modified to give good punching and shearing properties.

The metal used is generally copper which is produced in sheet form by a continuous electrolytic process. Most of this copper is 0.00135 inch in thickness and some of it is 0.0027 inch in thickness. The solution side of the copper is fairly rough which aids the bonding problem. Aluminum foil is also available and it adheres to laminates more readily than copper, but it has one serious handicap; it does not lend itself to dip soldering. If some method could be perfected for dip soldering of aluminum foil, it is believed that aluminum would replace much of the copper now used.

The adhesive is the third ingredient in this metal-clad laminate and it plays a very important role in the composite material.

The procedure for manufacturing a metal-clad laminate is briefly as follows: A continuous web of thin paper is passed through a solution containing a plasticized phenolic resin. In an oven, the solvent is removed by heat and the resin is advanced from the *A* stage to the *B* stage. The coated or impregnated paper which is now dry is then cut into squares approximately 38 by 38 inches. A few of these sheets, perhaps eight or ten, are piled into a stack. On the top of this stack is placed a sheet of adhesive film and on top of the adhesive film is placed a sheet of copper. The entire stack is then cured in a hydraulic press at 1,000 to 2,000 pounds per square inch pressure and 300 to 340 F heat for about 1 hour. This converts the resin to the *C* stage, where it is infusible and insoluble. Usually about 50 such sheets are pressed in one press load. There are variations to this procedure but roughly that is the process. If desired, the copper can be bonded to both sides of the laminate, and it often is.

Making a good laminate is no problem, but producing a good metal-clad laminate can be somewhat troublesome, and it might be well to consider that problem for a moment. What, for example, are the properties demanded of a metal-clad laminate? The base must be mechanically strong enough to resist bending, vibration, and mechanical and thermal shock. During fabrication this combination stock may be sawed, punched, routed, drilled, or milled. In use the component part may be in aircraft or other military applications receiving mechanical and thermal shock and vibration. The copper must not part from the laminate.

The adhesive must provide enough bond strength to hold the copper firmly to the laminate. But this is only one of a variety of requirements. The adhesive must be heat resistant. During fabrication of the printed circuit, an enamel is baked on the copper at 250 to 300 F for 30 minutes. In another operation the material is dipped in molten solder at 450 to 520 F for 2 to 5 seconds. Also, the component parts may be in service at 250 F for months, and at no time must the copper blister or lift from the laminate.

The adhesive-laminate combination must have a low dielectric constant, low dielectric loss factor, and very high insulation resistance and surface resistivity. In some applications it must have good arc and flame resistance. Furthermore, the combination must have good moisture

Full text of a paper presented at the AIEE–Institute of Radio Engineers Electronics Materials and Components Symposium, Philadelphia, Pa., June 2–3, 1955.

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resistance so as to maintain these good electrical properties even when the component is exposed to humid conditions.

To obtain all these plus values with one adhesive is a difficult task. Thermosetting adhesives have good electrical properties and good heat and moisture resistance, but they have poor bond strengths and poor shock resistance. The thermoplastic adhesives have good bond strength and good shock resistance, but poor heat resistance. For the present certain combinations of these resins are used.

Fabrication of the metal-clad laminate has developed a new industry. More than 100 companies offer some type of commercial design and fabrication service. Many of these companies process a foil-clad laminate exclusively. Although there are many variations, most processing methods utilize some form of photoetching to produce a circuit. Methods based on silk screening run a close second in popularity.

Adapted from standard plate-making procedures, photoetching begins with a glass or film negative made from a drawing of the required circuit. The surface of the foil-clad laminate is thoroughly scrubbed with pumice and water to remove all traces of foreign matter and oxide. An acid-resistant light-sensitive emulsion is applied to the foil surface and the coated sheet is then placed in a vacuum printing frame and exposed through the negative, using carbon arcs as the light source. The pattern is then developed in a "clod top" enamel which acts as a developer and as a resist to prevent etching. The enamel is then baked to harden.

The next step is to etch away the unwanted copper. This is generally accomplished as follows: first, immersing the coated foil-clad material in ferric chloride solution, then washing it in cold water, dipping it in a neutralizer, then giving it a second washing to complete the etching process. The removal can also be done electrolytically, but the more generally used method is the chemical bath.

The resist is then pumiced from the pattern and the finished sheet may be sawed, sheared, pierced, or blanked as required.

Silk-screen or offset methods are faster and far less complicated, but they are not particularly suited for fine-line work where really sharp definition is required. After thorough cleaning, the foil surface is coated with a vinyl resist through a silk-screen pattern. When the screen is removed the panel is baked and etched.

Other techniques for preparing printed wires are also used. These include the stamped-wiring method, the plated-wiring method, the embossed-wiring method, and the pressed-powder method. In the stamped-wiring method, no printing or etching is involved. Instead a stamping die is developed. The necessary dies are locked together in a plate having built-in electric heating units in a standard automatic toggle press. Thin sheets of laminate are stacked on the press for automatic feeding. Copper foil, coated with a thermosetting adhesive, is aligned on the press to be fed through the progressive dies. When the press is operated, the dies cut the circuit pattern and press the metal wires into the laminate. This process has two ad-advantages: it eliminates etching; and parts can be fabricated before the circuit is stamped, eliminating the danger of shrinking the laminate through various heating operations. Tooling costs, however, are relatively high and frequent circuit changes are not economically feasible.

The plated-wiring method uses an interesting deviation that warrants a brief description. In this process the laminate is first punched to the desired shape and design. The desired circuit is then printed on the panel in silver ink to form an electrode. The silver-ink pattern is then copper plated. Since the panel may be punched before the pattern has been applied, accurate registration is a simple matter. Also, those holes which have not been plugged will carry the circuit to the other side of the laminate, thus giving a continuous conductive pattern on both sides of each panel. The disadvantage of this process is the relatively weak bond between the copper and the laminate.

In the embossed-wiring method the copper-clad laminate is cured between embossed press plates instead of smooth press plates. This leaves hills and dales on the copper-clad sheet. The copper-clad sheet is passed through a sanding machine and all the copper hills are sanded off. The copper dales are left and become the wire pattern. This eliminates printing and etching, but unfortunately it does not produce fine lines.

Another method is the pressed-powder process. Silver dust is sprinkled over the bare laminate and a hot die is pressed against the sheet. The die presses silver into the laminate and these lines become the circuit. The unwanted silver dust is brushed away.

There are other processes, also, but no matter how the wires are formed the most interesting operation is now described. Every one is familiar with all the tubes, sockets, capacitors, resistors, etc., that a radio set contains. Each part has to be soldered to the next part and each soldered joint is a hand operation. With printed circuitry, this is all simplified. The laminate is held with the copper side down, the individual parts are placed in the proper holes, the entire assembly is dipped into molten solder, and the entire unit is soldered in one operation which takes but 2 or 3 seconds.

As can readily be seen, a great deal of thought has been put into techniques for producing printed-wiring boards. But in almost every case the board is a laminate, and the grade of laminate is usually *XXXP*. For some applications, where cost is of no importance, a glass-base grade bonded with epoxy resin or an orlon base bonded with diallyl phthalate is used.

Printed circuits are being used in many military applications at the present time and a host of new applications are being studied. Most of these are military secrets.

For civilian applications, printed circuits already are being used in radios, television sets, hearing aids, automatic signaling devices, and electronic office equipment. It is conceivable that printed circuits might be used in clocks, household gadgets, telephone apparatus, advertising signs, switchgear, and heating panels.

What the future holds nobody knows, but printed circuitry is here to stay and the plastics engineers are ready and willing to produce any laminate required.

Voltage Spread and Its Effect on Equipment

H. G. BARNETT
FELLOW AIEE

R. F. LAWRENCE
MEMBER AIEE

THE ADOPTION of higher secondary voltages in commercial areas involves careful consideration of suitable voltage spreads and, correspondingly, the plausible voltage levels for supplying utilization equipment. There is urgent need for the industry to select a level that will be generally suitable and acceptable, to avoid a variety of voltages in various parts of the country and a variety of equivalent ratings.

The comparison of the tolerable voltages for motors and fluorescent luminaires with the range of voltage usually provided by representative 120/280-volt secondary network systems in commercial areas is shown in Fig. 1. The difference between the usual range of voltage at the service entrance and that at the utilization devices is about 3 per cent, a commonly accepted value. The tolerable voltages for 118-volt fluorescent luminaires and 115-volt single-phase motors fit very well the usual range of voltage at the utilization devices. A 220-volt 3-phase motor usually will operate

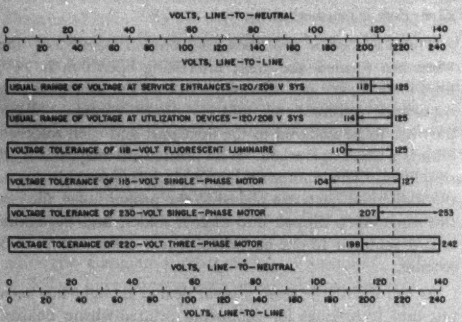
VOLTS, LINE-TO-NEUTRAL
VOLTS, LINE-TO-LINE
USUAL RANGE OF VOLTAGE AT SERVICE ENTRANCES-120/208 V SYS
USUAL RANGE OF VOLTAGE AT UTILIZATION DEVICES-120/208 V SYS
VOLTAGE TOLERANCE OF 118-VOLT FLUORESCENT LUMINAIRE
VOLTAGE TOLERANCE OF 115-VOLT SINGLE-PHASE MOTOR
VOLTAGE TOLERANCE OF 230-VOLT SINGLE-PHASE MOTOR
VOLTAGE TOLERANCE OF 220-VOLT THREE-PHASE MOTOR

Fig. 1. Comparison of tolerable voltages for motors and fluorescent luminaires, with the range of voltage usually provided by representative 120/208-volt secondary network systems in commercial areas

in the lower range of its voltage tolerance when supplied by a 120/208-volt system. Single-phase 230-volt motors are not likely to operate satisfactorily within the usual range of voltages at utilization points in a 120/208-volt system.

The comparison of tolerable voltage for motors and fluorescent luminaires with voltage ranges that can be provided by 265/460-volt and 240/416-volt systems is shown in Fig. 2. Both these voltages have been considered for commercial-area distribution. The voltage range at the service entrance and the utilization devices illustrated for both voltage levels is equivalent to that generally obtained in 120/208-volt systems. The tolerable voltages for 265-volt fluorescent luminaires and 440-volt 3-phase motors bracket the range of utilization voltages for the 265/460-volt system. A similarly suitable relationship occurs for 230-volt single-phase motors and 236-volt fluorescent luminaires.

Experience shows that the voltage spread of 114 to 125

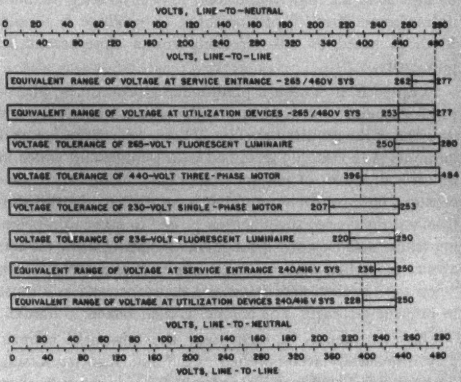
VOLTS, LINE-TO-NEUTRAL
VOLTS, LINE-TO-LINE
EQUIVALENT RANGE OF VOLTAGE AT SERVICE ENTRANCE - 265/460V SYS
EQUIVALENT RANGE OF VOLTAGE AT UTILIZATION DEVICES -265/460V SYS
VOLTAGE TOLERANCE OF 265-VOLT FLUORESCENT LUMINAIRE
VOLTAGE TOLERANCE OF 440-VOLT THREE-PHASE MOTOR
VOLTAGE TOLERANCE OF 230-VOLT SINGLE-PHASE MOTOR
VOLTAGE TOLERANCE OF 236-VOLT FLUORESCENT LUMINAIRE
EQUIVALENT RANGE OF VOLTAGE AT SERVICE ENTRANCE 240/416 V SYS
EQUIVALENT RANGE OF VOLTAGE AT UTILIZATION DEVICES 240/416 V SYS

Fig. 2. Comparison of tolerable voltage for motors and fluorescent luminaires, and voltage ranges that can be provided by 265/460-volt and 240/416-volt systems in commercial areas

volts in 120/208-volt systems has a satisfactory relationship to the tolerable voltage of utilization equipment.

CONCLUSIONS

Corresponding ranges of tolerable voltages for utilization equipment show that 253/438 to 277/480 volts and 228/395 to 250/433 volts are suitable spreads for 265/460- and 240/416-volt secondary voltages. The spread for 265/460 volts is favorable to 440-volt 3-phase motors and is suitable to 265-volt fluorescent luminaires. Considerable experience has developed with this voltage in industrial plants. An equivalent spread having an upper limit slightly below 480 volts would be more favorable. The higher voltage more effectively uses circuit capacity. The spread for 240/416 volts is favorable for 230-volt single-phase motors and is suitable for 236-volt fluorescent luminaires and appliances.

Obtaining a suitable spread of utilization voltage involves a careful allocation of voltage-drop limits in the various elements of the secondary-voltage system.

Digest of one of the 11 papers in special publication S-66, recommended by the AIEE Transmission and Distribution and Industrial Power Systems Committees and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954.

H. G. Barnett and R. F. Lawrence are with Westinghouse Electric Corporation, East Pittsburgh, Pa.

The Appraisal of Delays in "Gate Type" Operation

IMRE MOLNAR
MEMBER AIEE

In recent years an increasing amount of use has been made of "gate type" lockout circuits in telephone switching systems where a call, in the process of being completed, must pass temporarily through one or more control devices. Under such conditions, some delay occurs before service is given to the component connected to the gate. One of the purposes of the gate lockout circuit is to provide an equitable distribution of delays, where delays are unavoidable.

Calls which are delayed may be served either in order of their arrivals, or completely at random. In the first case, the delays will be completely equitable, but the equipment needed is fairly costly. In the second case, no special provisions are needed, but there is no equity in servicing the calls and extremely long delays are possible. Gate-lockout devices are relatively simple and inexpensive, and the resulting delay distribution will be between the two extremes. In most cases in practice, the resulting delays will approach the distribution with strict sequence service to an acceptable degree, and no extremely long delays will be experienced.

Disregarding details in design, a gate-lockout circuit is a switching device inserted between a group of sources originating calls and a lesser number of channels servicing these calls. The gate insures that a set of calls arriving prior to a certain instant will be served before subsequently arriving calls. The order of service within each set might be completely at random, or more often, as a matter of practical expediency, in order of precedence. This order may be determined by the location of each source in a circuit chain containing all sources, or by other arrangements prescribed by the details of the circuit design.

In the operation of a gate system, answers to a number of questions are of practical importance, such as the proportion of delayed calls, the average delay, the distribution of delays, the equity and preference in delays, the holding time of the gate, the average number of delayed calls, the number of gate operations in a given period, the average delays outside and inside the gate, the distribution of gate holding times, the distribution of calls entering the gate, the delays of individual sources, etc.

There is very little statistical material available to answer these questions; furthermore, to undertake a statistical study of this problem is a formidable task, considering the wide range of parameters involved and the huge sample size required to obtain meaningful results at the low probability levels which are of practical interest. Instead, it is possible to analyze the operation of these gate systems by mathematical means, employing the theory of probability.

Such theories for delay problems are available, with certain restricting hypotheses, for random and strict services, respectively. The theory of gate operation is obviously more complex than either of these; however, exact answers to several of the above questions can be obtained by an extension of the delay theory to gate operation, assuming the same restricting hypotheses. These are as follows: that statistical equilibrium exists; that traffic originates from a very large number of sources; that there is full availability from sources to channels; that the connection from sources to gate and to channels is instantaneous; that calls are originated at random; that no one source is preferred over any of the others as long as they are waiting outside of the gate, though once admitted to the gate they may be served in a certain fixed order of preference assigned to each source; and that calls enter the gate only when all channels are busy or if other calls are waiting. The answers to the remaining questions, to an accuracy sufficient for engineering purposes, can be obtained by employing numerical factors derived by interpolating judiciously between the random and strict sequence theories.

Such an analysis shows that the proportion of delayed calls, the average delays, and the average number of waiting calls are independent of the method of serving the calls. Therefore, they are the same for gate operation as for random or for strict sequence service. The average number of calls entering the gate is the same as the average number of waiting calls. The gate is occupied for a period less than the period during which all channels are occupied, in proportion to the per-cent occupancy of the channels. The number of gate operations is equal to the ratio of the total number of delayed calls to the average number of calls admitted to the gate. On the average, a call spends half its delay outside and half inside the gate. The distribution of gate-holding times follows the same law as the distribution of delays with strict sequence service. The distribution of the number of calls entering the gate follows the same law, by specifying a certain relation between the number of calls entering the gate and the gate-holding time. The distribution of delays can be obtained from the distribution of delays for strict sequence service by the application of a multiplier, varying from 1.0 to 1.3. The former applies to low channel occupancies and high probability levels, the latter to high channel occupancies and low probability levels, and will lead to conservative engineering. In general, with increasing number of channels, or with decreasing occupancy of the channels, gate-sequence service becomes indistinguishable from strict-sequence service. Practical examples demonstrate the performance of gate systems adapted for widely divergent applications, such as the common control automatic telephone systems or the answering of calls by operators.

Digest of paper 55-466, "The Appraisal of Delays in 'Gate Type' Operation," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 27–July 1, 1955. Published in AIEE *Communication and Electronics*, September 1955, pp. 475–85.

Imre Molnar is with the Automatic Electric Company, Chicago, Ill.

INSTITUTE ACTIVITIES

Unveiling the bust of Guglielmo Marconi. From left to right: Pietro Montana; Mrs. Paresce; M. D. Hooven; Giulio Marconi; and Vittorio Ivella.

Bust of Guglielmo Marconi Presented to AIEE by Sculptor Pietro Montana

A BUST of Guglielmo Marconi, executed by the noted Italian sculptor Pietro Montana, was presented by him to the AIEE in a brief ceremony in the lobby of the Engineering Societies Building, New York, N. Y., October 11. The bust will be placed in the Engineers' Hall of Fame, along with the portraits and sculptures of other great engineers and scientists.

The bust was received in behalf of the Institute by AIEE President Morris D. Hooven. Witnessing the ceremony were representatives of the Italian Embassy; the children of Marconi, Mrs. Gabriel Paresce, of Washington, D. C., and Giulio Marconi, of Italy; and officials and representatives of the engineering societies who use the Engineering Building.

H. S. Osborne, chairman of the AIEE Volta Scholarship Trustees, as master of ceremonies, stated that this gift united the AIEE with the engineers of Italy. He told about the Volta Scholarship by which a young Italian graduate engineer annually is brought to the United States for a year's study in an American engineering college. The present Volta scholar is Guiseppe Biorci, a student at Massachusetts Institute of Technology.

THE BAS-RELIEF shown above is in Freeman Hall, Fordham University, New York, N. Y., and was also executed by Pietro Montana. It was presented to the university by the Italian Professional Women of America.

THE AIEE VOLTA SCHOLARSHIP Trustee Chairman, H. S. Osborne (left), is shown speaking at the presentation ceremonies. Mr. Montana and Mrs. Paresce stand beside the bust of Marconi.

THE BUST OF GUGLIELMO MARCONI (1874–1937) presented to the AIEE on October 11, 1955 by Pietro Montana, the sculptor. Marconi's son, Giullo Marconi, posed for the bust. The bust was used as a model for the bas-relief shown on page 1096.

Mr. Osborne introduced Vittorio Ivella, the secretary of the Italian Embassy, who said that Marconi symbolizes scientific progress for his daring discoveries, and he expressed his appreciation on behalf of his countrymen for the addition of the bust to the Engineers' Hall of Fame.

Mr. Osborne then said that Marconi had been made an Honorary Member of AIEE on August 14, 1917 ". . . in recognition of his contributions to electrical engineering and its applications, notably. . . commercial application of radiotelegraph."

After Mr. Montana's presentation speech President Hooven, in thanking the sculptor, said that Italy had provided us with a background of science, typified by the discoveries of Galileo, Leonardo da Vinci, Alessandro Volta, and others through the centuries. He said that Marconi was the founder of the electronic age—that his concept of and insight into the electrical art were boundless. For instance, in the year 1922 it was Marconi who forecasted radar when he observed "a bouncing back of wireless waves."

Board of Directors Holds Regular Meeting in Chicago

THE AIEE BOARD OF DIRECTORS held its annual Fall Meeting in connection with the Fall General Meeting at the Morrison Hotel, Chicago, Ill., on Thursday, October 6, 1955.

Attending were President M. D. Hooven, Past President Elgin B. Robertson, Directors Donald I. Cone, M. S. Coover (part time), J. H. Foote, L. F. Hickernell, R. E. Kistler, E. S. Lammers, T. M. Linville, A. C. Muir, C. S. Purnell, J. D. Tebo, P. G. Wallace, J. C. Woods; Vice-Presidents B. G. Ballard, Bradley Cozzens, G. J. Crowdes, E. R. Jones, W. J. Miller, J. P. Neubauer, C. T. Pearce, S. M. Sharp, J. C. Strasbourger, C. M. Summers; Treasurer W. J. Barrett; Secretary N. S. Hibshman. By invitation: W. B. Morton, Chairman, Committee on Student Branches and AIEE Member of the Executive Committee, Engineers Joint Council (EJC).

The first order of business was the passing of resolutions expressing the regret of the board and extending sympathy to the family on the death of Director E. W. Seeger on August 28, 1955. (See "Obituary" section, *Electrical Engineering*, October 1955, page 947.)

Board of Examiners

The board took action approving the election of new members and the advancement of members in grade with the result that the following additions were made to the rolls of the Institute: 176 Members, 395 Associate Members, 49 Affiliates, and 45 Student members.

Unanimously elected to be invited to the grade of Fellow were David Beach Smith, vice-president in charge of research, Philco Corporation, Philadelphia, Pa., who was cited "for his work in establishing national color television standards and for his contributions to the radio and television arts," and Closman Paul Stocker, president and general manager, Lorain Products Corporation, Lorain, Ohio, who was cited "for his development of static ringing machines and dial tone generators." Pictures and biographical sketches of these two additions to the list of Fellows are included under "AIEE Fellows Elected" (pages 1110 and 1112).

Finances

The treasurer reported that the balance in the general funds in the Institute was $389,808.08, as compared with $231,946.09 on the same date last year.

Good news came with the Finance Committee which included comparisons of the receipt rate of dues income, as follows:

	1954	1955
Dues Collected First 5 Months	$465,121	$614,899
Total Dues Income for the Year	527,172	700,000*
Per Cent Collected (May through September)	88.23%	87.84%

*Budgeted

Resignations to date number 712 as against 303 for the same period last year. This is regarded as well within expected reactions to the recent increase in dues.

On motion of the Finance Committee, the board confirmed the effective date for the increase in registration fees at General and District Meetings as January 1, 1956. The basic action was taken originally at the meeting of August 17, 1955 setting the registration fees for members at $5 for General Meetings and $3 for District Meetings and for nonmembers at $5 for District Meetings and $8 for General Meetings.

The board also voted to refund the difference between the nonmember and member registration fees to nonmembers who join the Institute within 30 days after the meeting at which the nonmember registration fee was paid.

Proposals and Bylaws

The board reviewed the schedule for future General and District Meetings as published in the September issue of *Electrical Engineering*, page 852, and discussed several invitations for additions to the schedule but postponed action until a later meeting. An effort is being made to build the General and District Meeting Schedule 5 years in advance so that the pattern can be controlled by the Institute rather than the chance availability of hotel space.

A proposal to amend the Bylaws to remove the restrictions on exhibits in conjunction with General Meetings of the Institute was favorably discussed and referred for committee study and recommendation.

An article on the results of the 1955 Membership Opinion Poll conducted by the interview-sampling method was promised for the January issue of *Electrical Engineering*.

More polls or questionnaires are indicated for the near future by the need of the Committee on Technical Operation and the Publications Committee for better knowledge of the facts about the membership and its wishes and opinions.

Other Activities

A report of the Student Branches Committee relative to the program for 1955–56

was received, including a review of the September 9th meeting of the AIEE-IRE Student Branch Co-ordinating Committee which was attended by the presidents of the two Institutes.

Reports were heard on the activities of the Engineers Joint Council relative to the General Assembly planned for January 26–27, 1956, on the theme "Developing the Young Engineer"; and the Nuclear Congress to be held December 12–16, 1955 in Cleveland, Ohio.

President Hooven outlined the activities of the Engineering Manpower Commission of EJC in connection with the new reserve act which contains special provisions for scientists and engineers subject to Selective Service.

President Hooven, who is also Vice-President of The Engineers' Council for Professional Development, reported on the forthcoming 23rd Annual Meeting of Engineers' Council for Professional Development (ECPD) at Toronto, Ont., Canada, October 13–14, 1955 and the various problems confronting that organization. (See page 1105 for summary of meeting.) AIEE representatives are active in all phases of ECPD work. An expansion of the American Society of Engineering Education (ASEE) "Evaluation of Engineering Education" is contemplated.

The board received an invitation to be represented at the 100th Anniversary of the Verein Deutscher Ingenieure in 1956. It also authorized the Committee on Technical Operations to proceed in co-operation with the Sections and Districts to make plans for honoring Benjamin Franklin in 1956, which is the 250th Anniversary of his birth, and also Nicola Tesla on the centennial of his birth in the same year.

Appointments

Dean M. S. Coover of Iowa State College was elected to fill the vacancy created by the death of Director E. W. Seeger.

The following were elected as the board's representatives on the AIEE Nominating Committee, which will hold its Annual Meeting on January 30, 1956 in New York; J. H. Foote, E. R. Jones, R. E. Kistler, T. M. Linville, J. C. Woods. The following were elected to act as alternates to serve in the event that one of the five delegates to the board should be unable to attend the meeting; C. T. Pearce, C. S. Purnell, S. M. Sharp.

The board then elected Dean M. S. Coover to be a Member of the Edison Medal Committee and of the Lamme Medal Committee, and approved his appointment to the Committees on Registration of Engineers and Transfers to fill the vacancies left by the death of E. W. Seeger.

A 15-man Special Task Committee has been organized by the Five Societies to make another effort to reach agreement on a location and other problems related to a new Engineering Societies Center Building. AIEE is represented by E. S. Fields of Cincinnati, Ohio; J. E. Housley of Alcoa, Tenn.; and L. M. Robertson of Denver, Colo.

Fall General Meeting Sessions Held in Chicago, Ill., October 3-7

THE AIEE FALL GENERAL MEETING was held in Chicago, Ill., October 3–7, 1955, with headquarters at the Morrison Hotel. Approximately 1,750 members, guests, and students attended. This was the second of the three Fall General Meetings to be held in Chicago, the last being scheduled for October 1–5, 1956.

A variety of subjects was discussed in the 39 technical sessions, with special attention being given to communications system engineering, distribution, closed-circuit television, etc.

On the social side, there was a "Get Acquainted Tea" on Sunday afternoon before the sessions got under way next day. Monday evening there was a Smoker held in conjunction with the National Electronics Conference at the Morrison Hotel, and the following evening the two groups joined again in a Dinner-Dance at the Sherman Hotel. The ladies had a full and varied program, visiting many points of interest in the city.

LOOKING OVER THE PROGRAM at the Fall Meeting are (left to right): R. B. Gear, chairman of the Chicago Section, who presided and opened the meeting; A. V. Kahler, president, Illinois Bell Telephone Co., who gave the welcome address; J. A. Hutcheson, vice-president, Westinghouse Electric Corp., who also spoke at the General Session; and F. A. Cox, general chairman of the committee for the meeting.

General Session

Mr. Robert Gear, chairman of the Chicago Section, presided and opened the meeting with a request for general support of both the AIEE Fall General Meeting and the National Electronics Conference which were going on simultaneously at the Sherman Hotel. Mr. Francis A. Cox, general chairman of the 1955 Fall Meeting, introduced the members of the committee and thanked them for their services.

Mr. Gear introduced Mr. Kahler of the Illinois Bell Telephone Company, who made the address of welcome, and then introduced Morris Hooven, president of AIEE. (Mr. Hooven's talk appears on page 953, November 1955 issue of *Electrical Engineering*.)

Mr. J. A. Hutcheson, vice-president in charge of research and engineering, Westinghouse Electric Corporation was the principal speaker. He stated that the Chicago Section was organized in 1894 and began having regular meetings in 1902. He enumerated and illustrated the progress that has been made in the electrical arts and industries in the past 50 years.

The over-all efficiency of several generators has increased threefold since 1902; their weight and cost is about one-third as much per kilowatt-hour as in 1902. As far as the generator itself is concerned, its weight per kilowatt is only one-quarter what it was 50 years ago. Transformers have about half their former weight; core loss is about a quarter as much as it was then; the efficiency is markedly higher, and they cost about half what they did in 1902. Electric motors weigh and cost about one-quarter as much per kilowatt rating as they did in 1902. Incandescent lamps produce twice the light output as they did in 1915.

Mr. Hutcheson's opinion is that most equipment looks and operates much the same as it did 50 years ago; the big difference is in the use of materials. The new turbine blades are made of a material in which iron is regarded as an impurity. The yield strength of the material used for turbine rotors is double that of a few years ago. Silicon iron has been used in transformers since 1906, but the big difference today is that it is grain oriented. In 1906 only carbon-filament incandescent lamps were available. Tungsten lamps were developed about 1926; then the coil filament and, finally the coiled-coil filament.

When the *U.S.S. Nautilus*, the Navy's first atomic submarine, was built trouble was experienced with corrosion. The operating elements were imbedded in zirconium and it was found ultimately that the corrosion was the result of the presence of one part in a million of an impurity in the zirconium. The metallurgical improvement of materials in the last few years has been remarkable. It is only in the past 15 years that metallurgy has become a science; before this time it was more of an art. One part in a million of impurities will change the strength and characteristics of many metals.

The new development, of course, is that of solid state physics. It took about 10 to 15 years to understand and develop the vacuum tube; this is also true of transistors. A new discovery is the Hall effect by which the magnetic field under certain circumstances changes the conductivity of a conductor. A reverse thermocouple refrigerator is now a possibility and, except for the fact that it is only about half as efficient as the compressor-type refrigerators, is a practical reality. Electroluminescence has developed recently in such a way that it now seems possible to light a room by simply passing a current through the surface of a wall itself and the whole room becomes luminescent.

An interesting new development is cryogenics, which means the science of low temperature, such as −159 degrees where super conductivity occurs. As much as 8,000 amperes can be induced in a lead ring and the current will flow around the ring for a couple of weeks without diminution. On the other hand, passing a magnetic field through the material will stop it quickly. This opens the possibilities of conductivity control by the immersion of components in liquid nitrogen.

Automation is a broad term and often loosely used. Actually, we have automation if the term means automatic production. A lamp factory now turns out 10 lamps per second which represents already a high degree of automation.

In nuclear physics, the prospects of controlled fusion reaction seem likely. There is a possibility that we will be able some day to convert directly from nuclear energy to electrical energy. The United States Navy is now designing surface vessels to use nuclear power; the Air Force is also experimenting with nuclear power in an airplane; and the prospect of using it for direct heating are being developed.

One of the interesting future studies is the effect of radiation on materials. It seems possible that atomic radiation can be used to change the properties of material.

Technical Sessions

Insulated Conductors. Three papers were presented on rubber insulation which were considered to be timely. These were in the 5- to 25-kv range, and some indication was given that developments in this field tended toward an extension of the upper limit in the near future. One paper was given on the electrical breakdown of fully impregnated paper insulation for high-voltage cables that was considered valuable as a stimulus to research in this field.

X-ray Engineering. Four conference papers were presented at this session, one of the most interesting being on image amplification in cineradiography. With this development, motion pictures of the human body can be made with a lower radiation level and, because of the greater intensity of the pictures, motion can be stopped. In the industrial field pictures can be made through 1 inch of steel.

A phototimer that is dependent on X-ray radiations for its functioning was described by R. Godbarsen, Jr., General Electric Company. The timer is placed in the area of greatest interest, for example, in a chest X-ray picture, it is placed over the central lung area so that the heart shadow does not interfere. This X-ray detector depends on the film density and works into a photomultiplier tube and thyratron in the timing circuit.

Closed Circuit Television. Six papers were presented in two sessions. The paper, "Developments in Closed Circuit Television," by M. H. Kraus, Jerrold Electronics Corporation, described the installations at Fort Monmouth, N. J., and the Case Institute of Technology. (See pages 974–79, November 1955 issue of *Electrical Engineering.*) In the ensuing discussion, it was revealed that Signal Corps students learn more from "live" television lectures than from moving-pictures.

Similar results were described by Dr. Michael Klein at the University of Kansas Medical Center, where medical students and interns are instructed by closed-circuit television. Any unusual and difficult operations are sent from the operating theatres to television receivers in classrooms and other locations in the hospital.

A highlight of the afternoon session was the moving-picture film depicting some of the work at the National Institutes of Health which has been assisted greatly by the use of closed-circuit television. Dr. M. C. Brown, who directed the work, explained that it was being used in ways that are considered unorthodox today, but their results show promise. A series of microphotographs of the human retina were shown in color, which were considered to be an innovation in color television.

The question was asked about the relative evaluation of color and monochrome television in instructional programs. Dr. Brown stated that about 10 per cent of a large group had favored color television, the rest were contented with black-and-white images. Dr. Klein agreed with the survey, although much of the program was on surgical operations.

Wire Communications. Television technology has reached the stage where all equipment is subject to review to improve its performance. This was emphasized in a paper, "Local Television Facilities and Their Performance," by J. H. Enenback, Illinois Bell Telephone Company. In discussing "streaking" and "smearing," he said that the former was a brightness error in the picture resulting from vagaries in the frequency and phase response of the transmission system below 200 kc., and that smearing was a similar distortion but different in extent.

In a companion paper, H. R. Stevens, also of Illinois Bell Telephone Company, described frequency-attenuation equalizers which prevent distortion by attenuating frequency gain.

Design of Digital Computers. A project conceived in 1950 to obtain an additional research tool to supplement existing computer facilities, and to aid students and staff of the University of Wisconsin in the problems of computer design, construction, and maintenance, was described by members of the university's electrical engineering staff in a paper, "The Wisconsin Integrally Synchronized Computer—A Research Project." Construction started in 1952 and testing this fall. A working computer of unique design has been developed, simple to program, and sufficiently moderate in cost to be within the means of many institutions hitherto unable to justify a computer in its budget. Results in education and experience are reported to be invaluable.

System Engineering. J. H. Rixse, Jr., Rural Electrification Administration (REA), stated in his paper that system planning in the REA has become one of the most fundamental requirements. There are now 1,076 REA systems operating over a million miles of line, serving 4.25-million customers. These systems have borrowed some $3 billion from the Federal Government and 81 per cent of this is invested in the distribution plant. He foretold that energy requirements will double in 10 years and triple by 1975, and that these estimates increase the importance of system planning.

F. A. Cox, was the general chairman of the Fall Meeting Committee, with W. M. Ballenger, vice-chairman, H. R. Stevens, secretary, and R. W. Jones, treasurer. Chairmen of the various meeting committees were: M. J. Adams, dinner-dance; F. A. Larson, entertainment; F. M. Scott, finance and budget; E. R. Whitehead, general meeting; E. H. McNeill, hospitality; G. L. Welch, hotel arrangements; A. W. Kramer, publicity; G. E. Buchanan, registration; M. J. O'Laughlin, sale of papers; E. H. Finch, smoker; R. M. Bergslien, program; D. C. Pearcy, trips and transportation; Mrs. R. B. Gear, ladies activities; Mrs. F. A. Cox, reception tea; Mrs. F. A. Larson, registration desk; Mrs. M. J. Adams, ladies coffee hour; Mrs. E. H. Finch, ladies dinner; Mrs. H. R. Stevens, luncheon; and Mrs. W. E. Bergmann, tea.

Charles Erwin Wilson Receives the Washington Award for 1955

Charles Erwin Wilson, Secretary of Defense, has been selected to receive the 1955 internationally recognized Washington Award for his "significant leadership in engineering and management and for his altruistic devotion to national defense."

The Washington Award Commission is sponsored by the AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and is administered by the Western Society of Engineers of Chicago. Since the Award was founded by John W. Alvord in 1916, an engineer has been selected each year whose contributions to society have gone far beyond the fields of engineering and science. The first recipient of the award in 1919 was Herbert Hoover (AM '29).

During World War I, Charles Wilson was sent to Washington and designed and developed radio generators and dynamotors for the U. S. Army and Navy. He also developed a primitive crystal set, grand-daddy of the "walkie-talkie" for the infantry, and a little generator designed for wing mounting on the 1918 planes. He also designed the electrical equipment for the Army's "B" truck.

He made many contributions to the development and production of automotive electrical and ignition systems, and has held the top executive post of General Motors.

Charles Wilson has exerted a tremendous influence in improving the relations between management and labor. His "escalator" clause in long-term labor contracts and his "improvement factor" to increase labor's share in technological improvements changed the national thinking on labor relations.

Air View of the U. S. Merchant Marine Academy, Kings Point, Long Island, N. Y. An inspection trip is scheduled during the Winter General Meeting.

43 AIEE Technical Committees Plan 1956 Winter General Meeting

AGAIN THIS YEAR the Hotels Statler and Governor Clinton, New York, N. Y., will be used for the Winter General Meeting, January 30 to February 3, 1956.

As this issue goes to press 109 technical sessions are being planned by the 43 technical committees of the Institute. The committees on Rotating Machinery and Transmission and Distribution have announced six sessions each. In addition, there will be Switchgear, Power Generation, Transformers, Protective Devices, Substations, Insulated Conductors, Carrier Current, System Engineering and Relay sessions, all in the Power Division.

Committees in the Communication Division have completed their preliminary planning and have announced sessions on Communication Switching Systems, Special Communications Applications, Telegraph Systems, Information Theory, Radio Communications Systems, Wire Communications Systems, and Television and Aural Broadcasting Systems. In addition these last two committees have announced joint sessions with Transmission and Distribution, and Production and Application of Light Committees, respectively.

In the Industry Division technical meetings on Industrial Power Systems and the Metal Industry, Electric Welding, Chemical Industry, Industrial Power Rectifiers, Industrial Control, and Petroleum Industry and Feedback Control Systems are being organized.

The following committees in the Science and Electronics Division are also organizing sessions on Metallic Rectifiers Basic Science: Instruments and Measurements, Solid State Devices, Dielectrics, Computing Devices, Magnetic Amplifiers, Electronics, Electrical Techniques in Medicine and Biology, and Nucleonics.

Other meetings announced by committees in the Applications Division are on Land Transportation, Domestic and Commercial Applications, Production and Application of Light, and Marine Transportation. Among the general committees of the Institute sessions are being organized on Ethics, Management, Safety, Education, and Research.

Hotel Reservations

Blocks of rooms have been set aside at the Governor Clinton, Statler, and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent to the hotel of your choice, specifically referring to the AIEE meeting in your letter. Please do not write to more than one hotel. If your request cannot be filled, the hotel will automatically refer your request to the Hotel Accomodations Committee whose duty it is to obtain a similar reservation at another of the convention hotels for you. The hotel will confirm directly to you. No guarantee that you will be housed satisfactorily can be made if your request is received after January 16, 1956.

Because of the crowded conditions in New York hotels, it is suggested that your reservation be made for arrival on Sunday, January 29, 1956, thereby avoiding delays in registration or unavailability of rooms in the early morning of subsequent days. It is also suggested that a request for reservation prior to Christmas is more likely to be filled at the hotel of your choice.

Rooms have been allotted for our use by the following hotels at the daily rates indicated below:

Hotel Statler (meeting headquarters), 7th Avenue, 32nd to 33rd Streets	
Single room	$ 7.00 to $11.00
Double room	10.00 to 14.00
Twin bedroom	10.50 to 18.00
Suites	29.00 to 30.00
Hotel Governor Clinton (also used for meetings), 7th Avenue at 31st Street	
Single room	$ 6.00 to $11.00
Double room	8.50 to 14.00
Twin bedroom	10.00 to 16.00
Hotel McAlpin, Broadway and 34th Street	
Single room	$ 5.50 to $10.50
Double room	8.00 to 15.00
Twin bedroom	9.50 to 15.50
Hotel Commodore, Lexington Avenue and 42nd Street	
Single room	$ 6.00 to $11.50
Double room	9.50 to 14.00
Twin bedroom	11.00 to 17.00
Hotel Martinique, Broadway and 32nd Street	
Single	$ 5.00 to $11.00
Double room	8.00 to 14.00
Twin bedroom	8.00 to 14.00

All rooms have private bath and the rates quoted are subject to a 5 per cent New York City hotel room tax.

There will be no rooms available at the New Yorker or Roosevelt this year due to

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more people each year. Make it a point to attend this year—Sunday afternoon, January 29, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this period the registration facilities will be open for those wishing to avoid the Monday morning rush.

conflicts with other meetings, but allotments have been increased at other hotels accordingly.

Theater Tickets

As in the past, tickets to the following shows currently playing in New York will be available to AIEE members during the week of the meeting. All prices shown are brokers' prices.

	Evenings		Matinees
	M,T,W,T	F,S	W
A View from the Bridge Arthur Miller with Van Heflin, J. Carrol Naish	$6.85	$6.85	$5.15
Bus Stop William Inge with Kim Stanley	5.70	6.85	*5.15
Fanny Walter Slezak, Nicola Moscona	8.60	8.60	5.40
Inherit the Wind Melvyn Douglas	5.70	6.85	5.15
The Pajama Game Helen Gallagher, John Raitt	8.00	8.00	5.15
Plain and Fancy Richard Derr	8.00	8.00	5.25
Silk Stockings Cole Porter with Don Ameche, Hildegarde Neff	8.60	8.60	5.90
The Tea House of the August Moon Eli Wallach, John Beal	5.70	7.35	5.15
Tiger at the Gates Michael Redgrave	6.85	6.85	5.15
Witness for the Prosecution Agatha Christie with Francis L. Sullivan, Patricia Jessel	5.70	6.85	*5.15

*Mats. Thurs.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o S. Friend, Jr., 75 Buena Vista Drive, Dobbs Ferry, N. Y.

Smoker Committee

A highlight of the Winter Meeting will be the Smoker to be held on Tuesday evening January 31, 1956. Good food, good fellowship, and top quality entertainment will feature this event which will be held in the Hotel Statler.

Attendance will be limited to improve the comfort of guests and ticket requests should therefore be made at an early date. They should be addressed to D. Halloran, Room 1250 S, 4 Irving Place, New York 3, N. Y., and should be accompanied by checks made payable to "AIEE Smoker Committee." The ticket price will be $10 per person.

Dinner-Dance

A Dinner-Dance and President's Reception will be held on Thursday evening, February 2, in the Grand Ballroom of the Hotel Statler. General arrangements will be the same as those which proved so enjoyable last year. Dress will be formal. Plan now and write soon for tables for 10 or individual places. Address requests to: E. J. Doyle, American Telephone and Telegraph Co., 195 Broadway, New York 7, N. Y. Make checks payable to "AIEE Dinner-Dance Committee."

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until *December 31*. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before *December 31*.

55-699 **Nontracking Organic Insulations.** *R. S. Norman, R. A. Pfuntner, A. A. Kessel*

55-704 **Transfer Function and Parameter Evaluation for D-C Servomotors.** *G. J. Thaler, W. A. Stein*

55-828 **A Transistorized Overvoltage Relay.** *N. F. Schuh*

55-836 **Simplified Test Method for the D-Axis Transient Reactance and Time Constant.** *C. F. Yohe*

55-837 **Maximum Overvoltage on Aircraft A-C Generators After Sudden Removal of Load.** *R. E. Klokow*

Preprints may be purchased at 30¢ each to members, 60¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th Street, New York 38, N. Y.

Inspection Trips

A program of inspection trips is being arranged which will include, tentatively, the following places of general and technical interest: Brookhaven National Laboratory, Mahwah Assembly Plant of Ford Motor Company, Radio City Music Hall, Bell Telephone Laboratories (Murray Hill), United States Merchant Marine Academy, Kearny Station of the Public Service Electric and Gas Company, Steinway and Sons, Otis Elevator Company, American Telephone and Telegraph Company, Triangle Conduit and Cable Company, American District Telegraph Company, Charles S. Pfizer and Company, Fairless Plant of U. S. Steel Corporation, and the 59th Street Plant of New York City Transit Authority.

Ladies Entertainment

The Ladies Committee has planned a full week of activities for the Winter General Meeting. Some of the interesting events will be a "Get-Acquainted Tea," two tours of New York City, including upper and lower New York, United Nations Tour, luncheon and style show, and a daily coffee hour.

All ladies wishing to participate in these activities must be registered with their husbands before signing up at Ladies Headquarters, which will be open from 2 to 4 P.M. Sunday, January 29, 1956.

Registration Fees

With this General Meeting, registration fees have been increased to $5 for members and $8 for nonmembers. However, nonmembers applying for membership in the Institute within 30 days will receive a $3 credit toward their entrance fee. (See Board of Directors Report, section on Finances, p. 1097.)

Winter General Meeting Committee

Members of the 1956 Winter General Meeting Committee are: A. J. Cooper, chairman; D. M. Quick, vice-chairman; J. J. Anderson, secretary, J. P. Neubauer, vice-president District 3, and budget coordinator; J. D. Tebo, chairman, Committee on Technical Operations, F. S. Black, public relations; R. T. Weil, general session; Avery Gould, dinner-dance; D. V. Buchanan, hotel accommodations; J. V. O'Connor, inspection trips; Morris Brenner, registration; R. W. Gillette, smoker, R. R. Meola, monitors; S. Friend, Jr., theater and broadcast tickets; Mrs. Merwin Brandon, Ladies' Committee; C. T. Hatcher, ex officio member (past chairman).

Forum of Technical Committee Chairmen Held During the Fall General Meeting

THE FORUM of the AIEE Technical Committee Chairmen was held on Wednesday evening, October 5, at the Morrison Hotel, Chicago, Ill.

Dr. Julian Tebo, chairman of the Technical Operations Committee, opened this meeting and introduced AIEE President Morris Hooven, honorary chairman of the Forum, who told how the Forum came into being just before the start of the Korean War. Its purpose is to bring out the ideas, plans, and suggestions of members, which ordinarily are not heard during routine operations of technical committees.

Dr. Tebo then outlined the purpose of the Forum as a means for introducing new technical committee chairmen to their work. He outlined the arrangement of the Institute's Divisions and committees, both general and technical with the subcommittees of the latter, and how they are related to the Technical Operations Committee.

At the last Forum during the Summer General Meeting, it had been proposed that

a vice-chairman of each technical committee be appointed whose duty it would be to check on the availability of several necessities, such as a blackboard, projector, public-address system, etc., before the start of each session. It was decided that the appointment of a vice-chairman was not mandatory, but left to the discretion of committee chairmen.

Dr. Berberich suggested that advance programs of general and district meetings include the name of the sponsoring committee for each session. With this information, any correspondence necessary could be directed to the proper chairman.

Technical and Conference Papers

To dispel any misunderstanding which may have existed, Mr. E. C. Day was asked to explain the procedure for submitting, reviewing, and preprinting technical and conference papers. The reason for 90-day deadlines before meeting dates, is that it takes about a month for a paper to be reviewed and about 2 months to have it preprinted and distributed. He mentioned that a 120-day deadline was put on the papers for the Fall General Meeting because delays, due to vacations, were inevitable.

Mr. Day pointed out that some confusion existed regarding preprinting of conference or district papers. An abstract of the paper must be submitted to the committee chairman 75 days before the meeting date and the completed paper 15 days later, or 60 days before the meeting date if it is to be preprinted. He also mentioned that any publicity or programs intended for inclusion in *Electrical Engineering* should be given to him by the 20th of the second month preceding the date of issue, as the magazine deadline is the 25th of the month.

Session Plans for Meeting

Mr. J. P. Jordan, chairman of the Committee on Solid State Devices, called attention to the simultaneous session plans at general and district meetings, where sessions of similar interest are scheduled. Dr. Tebo explained that Mr. Day had circulated preliminary schedules for checking by committee chairmen for the 1956 Winter General Meeting in an effort to avoid such conflicting sessions, which are arranged, if possible, at the Committee on Technical Operations meeting. It was stated that it was difficult to determine the scope of the papers in a given session just from the titles, but it was felt that the Special Committee of Fifteen should take care of such matters in the future.

The feeling was expressed that no chairman wanted his committee to have a session scheduled for Friday afternoon. Mr. Day stated that he rotates these sessions among the different committees so that no one gets a Friday afternoon more than once every 5 years.

It was suggested by Dr. Berberich that as sessions devoted to Basic Sciences were poorly attended, it might be better if such papers were scheduled for sessions of other committees where there might be greater interest in them. Dr. Tebo suggested that other technical committees be consulted about this matter. He warned, however, that some of the Basic Sciences papers might have to be explained to the audiences in joint sessions so that their contents could be understood.

Suggestions for Future Meetings

Mr. Coggeshall stated that dissatisfaction had been expressed at a Communications Division Committee meeting concerning the attendance in general and thought that perhaps it was caused by inadequate advance publicity. It was suggested that division chairmen inform Raymond C. Mayer Associates which publications were thought to be best to carry publicity.

Dr. W. R. Clark, vice-chairman of the Committee on Technical Operations, discussed the forecast of Transactions and Conference papers for the coming year. It was emphasized that the number of papers and sessions were less this year than the previous year and that the forecast for next year continues this trend.

Dr. Tebo spoke about the large number of conference papers which were promised other publications even before their presentation at Institute sessions instead of being made available to *Electrical Engineering*. It is important that the Institute should have first call on these papers and technical committee chairmen should consider this need when setting up programs.

Mr. R. S. Gardner spoke about the duties of the chairmen of the technical committees and discussed the technical conferences. He said that complete instructions for handling these conferences were available and then discussed the method for getting the papers preprinted by the publication department. Mr. Day pointed out that conference papers must be submitted to Headquarters so that numbers can be assigned to them if they are to be preprinted.

Mr. Coggeshall asked for information concerning the financing of Technical Conferences, which was explained by Mr. Gardner.

Mr. Jordan asked if a conference could be held which would be by invitation only, as one particular conference was so largely attended that discussions of papers had to be limited in scope. Mr. Hickernell said that if the attendance is to be limited then a Special Committee should be appointed, and those invited to the conference would be committee members so that a committee meeting would be called instead of a conference.

Dr. Berberich asked about conference papers which were converted to technical papers. Such papers, Mr. Day replied, will be advertised in *Electrical Engineering* and in the three bimonthlies.

Nuclear Engineering and Science Congress, Atomic Exposition Open in Cleveland Dec. 10

ATOMIC ENERGY uses in industry, Government, education, medicine, and agriculture will be thoroughly discussed at the Nuclear Engineering and Science Congress to be held in Cleveland, Ohio, December 12–16. Engineers Joint Council (EJC) is co-ordinating the complex organization of the congress through E. Paul Lange, EJC secretary. This congress represents the biggest single project ever undertaken by the combined engineering and scientific societies of the nation. More than 25 organizations are operating, and almost 300 papers will be presented. Cleveland hosts for the congress are the Cleveland Engineering Society and the Cleveland Technical Societies Council.

All-Congress Dinner

One of the high points of the week-long gathering is the All-Congress Dinner on December 16th at the Statler Hotel. Admiral Lewis L. Strauss, chairman of the United States Atomic Energy Commission, will provide the keynote speech for more than 2,000 delegates to the congress. He will be introduced by Dr. John R. Dunning, dean of the Columbia University School of Engineering. Thorndike Saville, president of EJC and dean of the New York University College of Engineering, will make the welcoming address. Walker L. Cisler, president of Detroit Edison Company and chairman of the Atomic Industrial Forum, Inc., will be toastmaster.

List of Sessions

The following sessions are scheduled for the Congress. On Monday, December 12th, 1955: Safety and Site Selection for Reactors, Reactor Technology (another session also on December 13th), Reviews of Literature in Atomic Energy Fields, Reactor Technology—Heat Transfer, Heat Transfer and Fluid Flow, Radiation Damage to Structural Materials, Reactor Technology—Metallurgy and Alloys, Research Reactors and Radiation Laboratories, and Radioisotopes and Tracer Techniques. On Tuesday, December 13th: Safety Shielding and Remote Control I and II, Reactor Technology—Liquid Metals, Reactor Materials, Reactor Materials and Design, Analytical Methods and Facilities, Catalysis and Chemical Reactions, and Radiation Effects on Polymerization and Chemical Reactions. On Wednesday, December 14th: Instrumentation for Reactors, Reactor Control and Instrumentation, Reactor and Coolant Technology, Reactor Technology—Corrosion, Reactor Technology—Design and Construction, Materials and Metallurgy, Legal and Insurance Problems, Educational Requirements for Nuclear Engineering, Dissolution and Chemical Processing, and Chemical Separations (another session also on December 16th). On Thursday, December 15th: Reactor Technology.—Fabrication, Economics in Reactor Design, Chemical Processing and Separation, Detection and Monitoring of Nuclear Debris in Water, Chemistry of Solutions, Recovery of Fission Products, Reactor Analysis Techniques, Exploration and Production, Uranium Geology. On Friday, December 16th: Nuclear Characteristics of Fuel Assemblies, Accelerators, Removal of Fission Products from Aqueous Solutions, Disposal of Radioactive Wastes, Pollution Aspects of Radioactive Fall-Out, Nuclear Properties, General Papers, and Uranium Deposits.

AIEE Sponsored Papers

AIEE is sponsoring 13 technical papers to be presented during sessions on instrumentation and electric power applications. These include: "The Control of Heavy-Water Moderated Massive Fuel Reactors," E. Siddall, Atomic Energy of Canada, Ltd., Chalk River, Ontario, Canada; "The Bevatron Magnet Pulse-Timing System," W. C. Struven, University of California, Berkeley; "Dynamics and Control of Nuclear Power Plants," A. B. Van Rennes, J. C. Simons, Jr., and T. S. Gray, Massachusetts Institute of Technology, Cambridge; "Economic Power Fueling Without U-235 Enrichment," W. B. Lewis, Atomic Energy of Canada, Ltd., Chalk River, Ontario, Canada; "Reactor Instrumentation at Chalk River," Albert Pearson, Atomic Energy of Canada, Ltd.; "Power and Temperature Control of Pressurized Water-Cooled Reactors," W. H. Hamilton, J. N. Grace, O. R. Meyer, and N. E. Wilson, Westinghouse Electric Corporation, Pittsburgh, Pa.; "The Use of Computers to Determine Time-Dependent Fission-Product Distribution," J. V. Nehemias, R. C. Dennis, J. G. Lewis, and H. A. Ohlgren, University of Michigan, Ann Arbor; "A Nuclear Reactor Simulator for Teaching Purposes," L. Orr, W. Kerr, and H. J. Gomberg, University of Michigan; "Hanford Reactor Instrumentation," E. S. Day, Jr., General Electric Company, Richland, Wash.; "A Control System for Research-Type Nuclear Reactors," E. T. Davis, V. S. Underkoffler, and R. N. Brey, Leeds and Northrup Company, Philadelphia, Pa.; "A 25-Billion Electron Volt Proton Synchrotron," Martin Plotkin, Brookhaven National Laboratory, Upton, N. Y.; "Machine Sources of Ionizing Energy," J. G. Trump, Massachusetts Institute of Technology, Cambridge; and "Dual-Function System for Gamma Radiation Measurement," M. B. Leboeuf, R. E. Connally, and L. F. Miller, General Electric Company.

AIEE Representatives

Representatives of AIEE on the general committee of EJC are: Julian D. Tebo, Bell Telephone Laboratories, New York, N. Y.; and S. Reid Warren, Jr., University of Pennsylvania, Philadelphia; on the program committee: William E. Barbour, Jr., Tracerlabs, Inc., Boston, Mass.; and G. Wesley Dunlap, General Electric Co., Schenectady, N. Y.

Sponsoring and Supporting Groups

In addition to the societies, the congress is actively supported by private enterprise and the Government. The sponsoring groups, co-ordinated in this effort by EJC and its constituent societies, comprise more than half a million engineers and scientists, representing such apparently diverse fields as mining, metallurgy, sanitation, water supply, radio, electronics, chemical, petroleum, steel, nonferrous metals, aviation, automobile manufacture, rockets, architecture, ships, road construction, and city planning.

Atomic Exposition

The Atomic Exposition, running concurrently with the congress, supplementing its discussions of nuclear developments and displaying current actual tools of atomic developments, will be open on December 10. The general public, as well as registrants of the congress, will be able to view such items as: reactors, components, equipment, materials, and services in the atomic power field, many of which are displays of nuclear equipment being seen for the first time.

In announcing the world's first major Atomic Exposition, Professor Barnett F. Dodge, president of The American Institute of Chemical Engineers (AIChE), the organization directly sponsoring the show, said: "The exposition for the first time will bring together under one roof all the major developments in industry and science related to atomic energy. This includes not only atomic power developments, but also tremendously expanding applications of atomic by-products in all kinds of industrial fields. Suppliers to the various atomic industries are also being invited to display their latest developments relating to peacetime applications.

"Although attendance will be drawn chiefly from management and technical professions, the exposition will be open to the public at certain hours."

Space has been engaged by 140 exhibitors for the exposition, not only from the United States, but also from Canada, Great Britain, and Switzerland. These exhibits will occupy approximately 80,000 sq ft.

All U. S. firms participating in the commercial exhibit at Geneva, as well as most major U. S. firms who did not exhibit there, will be at Cleveland with their latest developments. Also working on exhibits are Atomic Energy Commission (AEC) Laboratories, universities, the Department of Commerce, Bureau of Standards, United Nations, and Quartermaster Food and Container Institute. An actual experimental reactor (noncritical) will be in operation.

Dates: December 10–16, 1955, inclusive.
Place: Cleveland Public Auditorium, Ohio.
Hours: December 10 and 11—2:00–10:00 p.m. (Open to industry and general public)
December 12—15—10:00 a.m.–10:00 p.m. (Open to public at 6:00 p.m.) December 16—10:00–5:00 p.m.

Special Events

A number of functions, including inspection trips in the area, will be sponsored throughout the week by the various societies singly and in co-operation. The AIEE Committee on Nucleonics will have a luncheon on Thursday, December 15th; the location will be announced at the congress.

Registration

A registration desk will be open at the Public Auditorium from 9:00 a.m. to 5:00 p.m. throughout the week. Preregistrations and hotel reservations will be handled by the Cleveland Engineering Society, 2136 East 19 Street, Cleveland 15, Ohio. The registration fee for the congress is $10.00. Registrants for the Nuclear Congress will be admitted to the Atomic Exposition without additional charge.

Hotel reservations for those attending the congress and exposition are available at five hotels: Statler, Carter, Cleveland, Hollenden, and Manger.

Registration fee for all others attending the exposition will be $2.00. (NOTE: Exposition registration *does not* entitle the registrant to attend Nuclear Congress sessions.)

Future AIEE Meetings

EJC-AIEE Nuclear Energy Conference
Cleveland, Ohio
December 12–17, 1955
(*Final date for submitting papers—closed*)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1956
(*Final date for *TP—closed, †CP Syn. —closed CP Ms—closed*)

AIEE-IRE-ACM Western Computer Conference
Fairmont Hotel, San Francisco, Calif.
February 8–10, 1956
(*Final date for submitting papers—closed*)

AIEE-IRE-University of Pennsylvania Transistor Circuit Conference
University of Pennsylvania
Philadelphia, Pa.
February 16–17, 1956
(*Final date for submitting papers—closed*)

Scintillation Counter Conference
Shoreham Hotel, Washington, D. C.
February 28–29, 1956
(*Final date for submitting papers—closed*)

Southern Textile Conference
Georgia Institute of Technology, Atlanta, Ga.
March 1–2, 1956
(*Final date for submitting papers—Dec. 1*)

Paper and Pulp Conference
University of Florida, Gainesville, Fla.
March 8–9, 1956
(*Final date for submitting papers—Dec. 8*)

AIEE, University of Illinois American Power Conference
Sherman Hotel, Chicago, Ill.
March 21–23, 1956
(*Final date for submitting papers—Dec. 21*)

South West District Meeting
Dallas, Tex.
April 2–4, 1956
(*Final date for TP—Jan. 3, ‡DP Syn.—Jan. 18 DPMs—Feb. 2*)

Great Lakes District Meeting
Fort Wayne, Ind.
April 16–18, 1956
(*Final date for TP—Jan. 16, ‡DP Syn.—Feb. 1 DPMs—Feb. 16*)

AIEE, ASME, ISA Recording and Controlling Instruments Conference
Bradford Hotel, Boston, Mass.
April 26–27, 1956
(*Final date for submitting papers—Jan. 26*)

North Eastern District Meeting
Rochester, N. Y.
May 2–4, 1956
(*Final date for TP—Feb. 1, ‡DP Syn.—Feb. 15 DPMs—March 2*)

*TP—Transactions paper
†CP SYN.—Conference Synopsis
CP MS—Conference Manuscript
(The CP Syn. date is 15 days before the CP Ms date)
‡DP SYN.—District Synopsis
DP MS—District Manuscript (the DP Syn. date is 15 days before the DP Ms date)

Purpose and Scope of the Congress

Thorndike Saville, president of EJC, summed up primary purposes of the congress as follows: "The horizon for the peaceful application of atomic developments, as yet, are not even imagined. This highly interrelated family of developments is very much in the 'idea-for-application' stage. Therefore, it is of enormous importance to present to those interested a panoramic view with detail as a proper measure of current opportunity and the vastness of potential. Progress for the Congress already indicates that it will be the largest gathering of engineers and scientists ever held in the United States to discuss nuclear energy. As such, it will be a major opportunity for the communication of ideas and developments among the many thousands of persons in industry, business, agriculture, and medicine, for whom the technology of the atom is increasingly important."

The basic objective of the congress is to launch a continuing program of interchange of information on the developing applications of nuclear science by the engineer and scientist for vital national benefits involving industry, agriculture, medicine, and public welfare.

Major Fields of Interest

Some of the representatives on the general committee, and the major fields of interest follow:

Instrumentation, and electric power application, AIEE (J. D. Tebo, Bell Telephone Laboratories, New York, N. Y., and S. R. Warren, Jr., University of Pennsylvania, Philadelphia).

Radiation effects on structural materials, American Society of Civil Engineers (J. M. Garrelts, Columbia University, New York, N. Y.).

Radiation damage and solid fuels, American Institute of Mining and Metallurgical Engineers (J. H. Frye, Jr., Oak Ridge National Laboratories, Oak Ridge, Tenn.).

Heat transfer, reactor design, instrumentation, and safety, The American Society of Mechanical Engineers (A. D. Bailey, New York, N. Y.).

Radioactive material in waste, detection, and treatment, American Water Works Association (R. J. Faust, assistant secretary, New York, N. Y.).

Marine nuclear propulsion, The Society of Naval Architects and Marine Engineers (D. C. MacMillian, president, George G. Sharp, Inc., New York, N. Y.).

Atomic energy education, The American Society for Engineering Education (P. N. Powers, director atomic project, Monsanto Chemical Co., St. Louis, Mo.).

Liquid metals, reactors, and chemical manufacture, American Institute of Chemical Engineers, Prof. Manson Benedict, Massachusetts Institute of Technology, Cambridge, Mass.).

Industrial, physical, and inorganic chemical applications, American Chemical Society (J. G. Warner, president, Carnegie Institute of Technology, Pittsburgh, Pa.).

Reactor physics, American Institute of Physics (Dr. Clark Williams, Brookhaven National Laboratory, Upton, N. Y.).

Nuclear physics and engineering, American Nuclear Society (Jerome Luntz, editor *Nucleonics*, New York, N. Y.).

Nuclear industry management, Atomic Industrial Forum (Charles Robbins, director, New York, N. Y.).

Nuclear applications, Institute of Aeronautical Sciences (S. P. Johnston, director, New York, N. Y.).

Nuclear energy source material, American Geological Institute (Paul F. Kerr, executive director, American Geological Institute of National Research Council, Washington, D. C.).

Joint Meeting Held by Ohio District 11 and Student Activities Committees

The first meeting of the newly created District 11 Executive Committee was unusual in several respects. As pointed out by Vice-President J. C. Strasbourger, the meeting was held jointly with the Student Activities Committee to obtain the best Section-Branch co-operation. The meeting was held in the country at the Golden Lamb Hotel, Lebanon, Ohio, September 30 and October 1, 1955.

Mr. E. S. Fields, vice-president of the Cincinnati Gas and Electric Company, Ohio, and past vice-president from District 2, 1945 to 1947, addressed the dinner-meeting on the evening of September 30. Mr. Fields talked about the Cincinnati program which is a co-operative activity of Engineers' Council for Professional Development between industries in the vicinity and the University of Cincinnati for the first 5 years of professional development. This program for continued education after graduation and the integration of the young engineer into the community has been highly successful.

Election Procedure

The election procedure was explained by Vice-President J. C. Strasbourger, as well as the duties of the vice-president to visit every Branch, Section, and subsection within the District at least once a year. After nominations were duly made and seconded, the Executive Committee elected George R. Canning, chairman of the Cleveland Section, as delegate to the Nominating Committee with W. R. Hough as alternate. The delegate was informed of the adequacy of the candidates Walter B. Morton for president, Clarence Beller of the Cleveland Section for director, and Walter J. Barrett for treasurer. Henry H. Kerr was nominated for vice-president of District 11 by the District Executive Committee.

Luncheon

At the conclusion of the District Executive Committee meeting, a joint luncheon was held with the Student Activities Committee and was addressed by Joseph W. Ritter-

VICE-PRESIDENT J. C. STRASBOURGER (top) introducing the dinner speaker on his left, E. S. Fields, vice president of the Cincinnati Gas and Electric Company and AIEE past Vice-President, at the first District 11 Executive Committee Meeting. (bottom). At the Golden Lamb Hotel, Mrs. J. C. Strasbourger and George R. Canning, Chairman of the Cleveland Section, look over the display.

house, technical director, Hi-Voltage Equipment Company, on the subject of "Co-operation Between Branch and Section." Speaking from experience as a former counselor at the Missouri School of Mines, Mr. Rittenhouse enthusiastically spoke of Section–Branch co-operation and the need for strong, friendly relationships. The Branches and the Sections must thoroughly understand each other and co-operation becomes extremely difficult if misunderstandings should occur. It takes a counselor a long time to recover from the effects of a poor speaker after addressing the first Branch meeting in the fall. The Sections should invite Branch personnel to participate in Section activities, and the Sections should develop groups of people for speakers who have proved their ability to interest students.

In the afternoon, an inspection trip was taken to the Crosley Government Products plant, where radar, servomechanisms, and electronic development work was in progress. After the dinner in the evening, transportation was arranged from the hotel to the Lebanon harness racing.

Joint Meeting

A joint meeting of the District Executive and Student Activities Committees was held October 1st. The work of the Student Branches Committee and subcommittees was outlined by Walter B. Morton, chairman. The students should assist with suggestions to their counselors, who in turn give them to Professor Evert. He would give the suggestions to the Committee on Student Branches. Chairman W. B. Morton strongly urged the students to enter the Prize Paper Competition as this would help them to speak and write more effectively in industry.

The meeting was addressed by Secretary N. S. Hibshman, who told of some of the work being done by the Board of Directors and the Planning and Co-ordination Committee. This committee is studying the "why" in a number of areas with the help of a professional group. Secretary Hibshman spoke of the early organization of the engineering profession and stressed that organization enabled men to do things that they could not do as individuals. If members used the AIEE as a means of expressing themselves in the profession and contributing to the profession, they would obtain indirect rewards, and the Student Branch was an excellent vehicle to begin such a service.

The remainder of the meeting was devoted to the ways and means of obtaining good Branch–Section co-operation. Views were exchanged in discussion of prize awards competitions, prizes, membership, and father-and-son dinners. That the meeting was successful was attested to by several of the Student Branch chairmen and students who were enthusiastic and complimentary.

Survey of Engineering Profession Proposed at Annual ECPD Meeting

A RESOLUTION recommending that the Engineers' Council for Professional Development (ECPD) sponsor a comprehensive survey of the engineering profession was proposed at the Twenty-Third Annual Meeting of ECPD held at the King Edward Hotel, Toronto, Ont., Canada, on October 13–14, 1955.

At the luncheon meeting the first day, S. C. Hollister, dean of the College of Engineering, Cornell University, Ithaca, N. Y., gave a talk, entitled "Survey of Education and Utilization of Engineers," presenting the resolution for subsequent panel discussion. The resolution was formulated originally in 1954 at an informal 2-day meeting of engineering deans at Ithaca, N. Y. In his address S. C. Hollister stated: "It would seem clear that everybody stands to gain by a well-executed study of this sort. First of all, the community would be served by any improvement that could be brought about in the functioning of our important profession. Those immediately concerned with function, namely, the employers of engineers and the engineers themselves, would profit both individually and collectively by such a well-designed and well-executed survey. And, finally, such a survey should lay the groundwork for improvement and better definition of the engineering profession as a whole."

On the second day, an open forum was conducted on this item. The panel discussion was led by Warren L. McCabe, administrative dean, Polytechnic Institute of Brooklyn, N. Y., with the assistance of the following panel: H. N. Meixner, staff assistant, engineering department, E. I. du Pont de Nemours & Company (Inc.), Wilmington, Del.; M. D. Hooven, engineering department, Public Service Electric & Gas Company, Newark, N. J.; R. M. Hardy, dean of engineering, University of Alberta, Canada; T. Saville, dean of engineering, New York University; and W. L. Everitt, dean of engineering, University of Illinois. At the conclusion of the discussion on the Hollister proposal, which had audience participation, the Council passed a resolution addressed to the Executive Committee requesting that it proceed with plans for conducting the proposed survey and find appropriate leadership and financial support for it.

Resolution

The text of the resolution for a survey of the engineering profession adopted at the annual meeting is as follows:

WHEREAS: The Profession of Engineering has ever increasing responsibilities in the rapidly expanding technological aspects of our civilization, and

WHEREAS: these public and professional responsibilities are becoming increasingly complex, and

WHEREAS: the numbers of engineering personnel being trained is both limited in supply and inadequate in numbers to discharge the needs under the present organization of the profession, much less those of the future, and

WHEREAS: the situation confronting the profession is charged with important social, economic, and political aspects in the interest of the public welfare, and

WHEREAS: in the light of these serious public and professional problems a study of the profession is called for, now therefore

LET IT BE RESOLVED: That Engineers' Council for Professional Development sponsor a survey of the engineering profession to include the present and prospective needs for engineering services, the improvement in the utilization of engineers and supporting technical personnel, the scope and nature of the education and training required, the problems of registration, unionization and ethics involved, and all other matters pertinent to determine the most effective organization of the profession to meet its public responsibilities and professional opportunities, and

BE IT FURTHER RESOLVED: that Engineers' Council for Professional Development seek the concurrence of its Constituent Societies in undertaking such a survey, and

BE IT FURTHER RESOLVED, that Engineers' Council for Professional Development refers this resolution to its Executive Committee for implementation.

Annual Dinner

The feature of the annual dinner was an address, "Engineering Bodies," by Sidney Smith, president, The University of Toronto. M. D. Hooven, vice-president ECPD and president AIEE, presided.

The ECPD was organized to enhance the professional status of the engineer through the co-operative efforts of the following national organizations, which are constituent members concerned with the professional, technical, educational, and legislative phases of engineers' lives: AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, The Engineering Institute of Canada, American Society for Engineering Education, American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners. ECPD is best known for its work of accrediting technical curricula in the engineering colleges.

Criteria for Accreditation Announced by ECPD

To assist identification and recognition by Engineers' Council for Professional Development (ECPD) of the accreditation of curricula that constitute adequate undergraduate educational preparation for the engineering profession, the following criteria, supplemental to those regularly published in the Annual Report of ECPD under "Objectives and Procedures for Accrediting Engineering Curricula," will serve as a guide in ECPD accrediting activity. The object of the criteria is the assurance of an adequate foundation in the sciences, humanities, engineering science, and engineering methods. Sufficient flexibility is provided in science requirements to accommodate curricula requiring special backgrounds, and for expression of the institution's own individuality and ideals. Finally, the criteria is regarded as a statement of principles to be applied with judgment in each case rather than with arbitrary rigidity.

The supplemental criteria are:

1. All curricula shall contain at least the equivalent of one academic year of mathematics and basic science about equally divided.

2. All curricula shall contain at least the equivalent of approximately 1 year, except as provided in paragraph *3* of engineering sciences, including most and preferably all of the following: mechanics of solids (statics, dynamics, strength of materials), fluid mechanics, thermodynamics, transfer and

rate mechanisms (heat, mass, momentum transfer), electrical theory (fields, circuits, electronics), and the nature and properties of materials (relating particle and aggregate structure to properties). Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum.

3. Because some engineering curricula are built in part on sciences not included in the preceding paragraphs, such curricula may contain for additional flexibility other basic or engineering sciences appropriate to their fields, to an extent equivalent to one-third of an academic year, in lieu of an equal portion of time otherwise devoted to the engineering sciences listed in *2*.

4. Approximately the equivalent of one half of an academic year shall be devoted to engineering analysis, design, and engineering systems.

5. The curriculum shall be designed for an integrated sequential study in the scientific and engineering area. The mathematics and the basic science to be used proficiently in the work in engineering analysis, in the study of engineering systems, and in the preparation for creative design.

6. The equivalent of one-half year to one full year of the curriculum shall represent the minimum content in the area of humanistic and social studies. Of this content, at least one-half year should be selected from the fields of history, economics, Government, literature, sociology, philosophy, psychology, or fine arts, and should not include such courses as accounting, industrial management, finance, personnel administration, or Reserve Officer Training Corps (ROTC).

7. The two pressures on 4-year engineering curricula for inclusion of more newly developing engineering science and for an increase in the social-humanistic content makes it necessary that neither the technical-scientific nor the social-humanistic content of such curricula be reduced below the minimum requirements of the supplemental criteria to make room for advanced ROTC programs. This procedure views realistically the fact that the engineering student taking advanced military science is in effect pursuing two curricula simultaneously with separate and different requirements and objectives.

In any case in which the Education and Accreditation Committee is persuaded that well-considered experimentation in engineering curricula is under way, it shall give sympathetic consideration to departures from the criteria and shall make appropriate recommendations to ECPD.

The committee recognizes that these recommendations constitute a departure from past practice in that an approach is made to quantitative criteria as to curriculum content and distribution of time.

The committee continues to favor broad basic undergraduate programs in engineering which will prepare a student to take advantage of as many different opportunities as possible, and prefers to minimize the number of specially designated curricula to be considered for accreditation. The committee is prepared to examine for approval any curriculum that appears likely to satisfy its criteria for an undergraduate engineering curriculum.

Curricula of a vocational or technical institute pattern cannot qualify nor can curricula of so specialized a pattern as to provide an inadequate base for engineering of professional level.

1955 Winners Announced for Eta Kappa Nu Awards

The award of "Outstanding Young Electrical Engineer for 1955" has been made to Wilbert E. Chope (AM '50), president of the Industrial Nucleonics Corporation, Columbus, Ohio, as announced by the Jury of Award, Eta Kappa Nu, which met October 15, 1955. The award is made annually to the young engineer of outstanding accomplishment who is not older than 35 years of age and not out of school more than 10 years.

Mr. Chope obtained a bachelor of science

W. E. Chope

degree from Ohio State University and later a master of science degree in electrical engineering and business administration from the Massachusetts Institute of Technology.

Honorable mentions went to John N. Grace (AM '52), senior scientist, Atomic Power Division, Westinghouse Electric Corporation, Pa.; H. R. Johnson, Hughes Research and Development Laboratories, Calif.; D. B. Shuster, Sandia Corporation, N. Mex.; and Glen Wade, Applied Electronics Laboratory, Stanford University, Calif. It is interesting to note that both W. E. Chope and J. N. Grace are in nuclear work. Further details concerning the awards and the recipients are scheduled for publication in the January issue of *Electrical Engineering*.

AIEE Nominating Committee Meets in New York City

The AIEE Nominating Committee will meet in the Hotel Statler, New York, N. Y., on January 30, 1956, during AIEE's Winter General Meeting to nominate candidates for offices to be voted on by the membership in the spring of 1956. It is hoped that a complete listing will appear in the January issue of *Electrical Engineering*. Some members of the committee follow:

Representatives for the eleven geographical Districts are:

1. E. K. Rohr, General Electric Company, 920 Western Avenue, Lynn, Mass.

2. A. C. Muir, Berwind-White Coal Mining Company 1400 Pennsylvania Building, Philadelphia 2, Pa.

3. R. T. Weil, Jr., Manhattan College, New York 63, N. Y.

4. W. F. Criley, Department of Electric Engineering, Vanderbilt University, Nashville, Tenn.

5. J. R. North, Commonwealth Services, Inc., 252 West Cortland Street, Jackson, Mich.

6. District Executive Committee Meeting scheduled for October 31 or November 6, 1955

7. District Executive Committee Meeting scheduled for November 10, 1955

8. W. G. Collins, Pacific Tel. & Tel. Company, 140 New Montgomery Street, San Francisco, Calif.

9. J. A. McDonald, General Electric Company, 200 S. Main Street, Salt Lake City, Utah.

10. District Executive Committee Meeting scheduled for November 8, 1955

11. G. R. Canning, Ohio Bell Telephone Company 750 Huron Road, Cleveland, Ohio

Alternates for District representatives:

1. R. Cutts, Jr., General Electric Company, 1 River Road, Schenectady 5, N. Y.

2. H. H. Sheppard, Rumsey Electric Company, 1007 Arch Street, Philadelphia 7, Pa.

3. W. A. Clark, American Tel. & Tel. Company, 195 Broadway, New York, N. Y.

4. Thomas Salisbury, Gregory-Salisbury & Company, Jackson, Miss.

5. W. L. Cassell, Department of Electrical Engineering, Iowa State College, Ames, Iowa

9. J. A. Davis, 1455 Crandall Ave., Salt Lake City, Utah

11. W. R. Hough, Reliance Electric & Engineering Company, 1088 Ivanhoe Road, Cleveland 10, Ohio

Representatives for the ten technical Divisions are:

Communication—I.S. Coggeshall, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y.

General Applications—R. L. Oetting, General Electric Company, Nela Park, Cleveland 12, Ohio

Industry—G. W. Heumann, General Electric Company, 1 River Road, Schenectady 5, N. Y.

Power—C. T. Hatcher, Consolidated Edison Company, of New York, Inc., 4 Irving Place, New York 3, N. Y.

Science and Electronics—S. Reid Warren, Jr., University of Pennsylvania, 220 South 33rd Street, Philadelphia, Pa.

Alternates for Division representatives:

Communication—John Meszar, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y.

General Applications—T. C. Johnson, General Electric Company, 5 Lawrence Street, Bloomfield, N. J.

Industry—C. N. Clark, Duquesne Light Company, 435 Sixth Avenue, Pittsburgh, Pa.

Power—E. I. Pollard, Elliott Company, Ridgway, Pa.

Science and Electronics—J. G. Reid, Jr., ACF Electronics, 800 North Pitt Street, Alexandria, Va.

Representatives for the Board of Directors:

J. H. Foote, Commonwealth Services, Inc, 252 West Cortland Street, Jackson, Mich.

E. R. Jones, Mountain States Tel. and Tel. Company, Box 960, Denver 1, Colo.

R. E. Kistler, Pacific Tel. & Tel. Company, 1200-3rd Avenue, Seattle, Wash.

T. M. Linville, General Electric Company, Research Services Division, P. O. Box 1088, Schenectady, N. Y.

J. G. Woods, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.

Alternates for Board representatives:

C. T. Pearce, Westinghouse Electric Corporation, 3001 Walnut Street, Philadelphia 4, Pa.

C. S. Purnell, Westinghouse Electric Corporation, 600 St. Paul Avenue, Los Angeles 17, Calif.

S. M. Sharp, Southwestern Gas & Electric Company, Shreveport, La.

The following Bylaws of the Institute make it possible for the membership as a whole to make suggestions and to put forward the virtues of candidates to the Nominating Committee. It may be of interest to see Mr. Hickernell's article on page 278 of the April *Electrical Engineering* for a clarification of the Institute's election procedure.

Constitution

Article VI

31. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as Vice-President of that District, or four filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

32. The Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The Nominating Committee shall name, on or before January 31 of each year, one or more candidates for President, Treasurer, and the proper number of Directors, and shall include in its ticket such candidates for Vice-Presidents as have been named by the nominating committees of the respective geographical Districts, if received by the Nominating Committee when and as provided in the Bylaws; otherwise the Nominating Committee shall nominate one or more candidates for Vice-President (s) from the District (s) concerned.

Hundred Year Association Medal Awarded at Annual Dinner

David Sarnoff (M '23, F '51), chairman of the board of Radio Corporation of America, has been presented with the 1955 gold medal of the Hundred Year Association of New York in recognition of his work as

D. Sarnoff

"pioneer, founder, and leader in electronic communication."

The presentation was made by Mayor Robert F. Wagner at the association's Annual Dinner at the Waldorf-Astoria Hotel, New York, N. Y. The citation said General Sarnoff's "... accomplishments as a civic leader, patron of the arts, and head of the Radio Corporation of America make him the embodiment of the ideal of equal opportunity at work in a free society."

Among the tributes read at the dinner was one from Dwight D. Eisenhower, President of the United States. The President, in a letter to Howard S. Cullman, chairman of the dinner committee, praised General Sarnoff: "Through his brilliant accomplishments in the field of communications and his devoted and enlightened services to his country, he has contributed much, in the course of a distinguished career, to the welfare of his fellow men and to the cause of freedom and peace in the world."

In accepting the Gold Medal award, General Sarnoff said that "... dramatic as the advances in the past century have been, they are certain to be dwarfed by far-reaching changes to come."

A half-hour radio program covering the presentation of the medal was transmitted to Latin America on four shortwave bands by Station WRUL of the World Wide Broadcasting System, whose president, Walter S. Lemmon, arranged for the program as a tribute to General Sarnoff's pioneering contributions to international radio communications and broadcasting. Next year, General Sarnoff observes his 50th anniversary of service in the radio field.

David Sarnoff Fellowship Awarded to Engineering Student

Lawrence D. Wechsler (AM '55), has been chosen to receive the David Sarnoff Fellowship at the New York University College of Engineering for the 1955–56 academic year.

The $3,500 award is given annually by the Radio Corporation of America. It is designated for the New York University (NYU) student who, in the opinion of the faculty, shows the greatest promise of achievements in the field of electronics and communications.

Mr. Wechsler graduated from the Bronx

Lawrence O. Wechsler

High School of Science in 1945. From 1950 to 1952 he served as a sergeant with the United States Army in Germany. He attended NYU and received the degree of bachelor of electrical engineering last June, graduating summa cum laude and first in his class.

He will use his fellowship to study toward a master's degree in electronics, specializing in electronic computer techniques. During the past summer he was employed in the Research Division of the NYU College of Engineering.

As an undergraduate, Mr. Wechsler was president of Eta Kappa Nu, honorary electrical engineering society, and was a member of Tau Beta Pi, honorary engineering society. He also has won the $1,000 Hugo Gernsback Award and the James Loring Arnold Prize at NYU.

Annual AIEE Prizes in Various Classifications

The following is a reminder of the awards which are available each year in classification:

1. *Institute*

Class	First Prize	Additional Prize
1. (a). Each Division Communication General Application Industry Power Science and Electronics	$100 and certificate	Certificate (In special cases additional certificates may be awarded at the discretion of the Committee on Prize Awards for Institute papers.)
(b). Paper outside Division jurisdiction	$100 and certificate	None
(c). Best Student paper	$100 and certificate	Certificate

2. *District*

Class	First Prize	Additional Prize
(a). Best paper, any class	$75 and certificate	$50 and certificate.
(b). Best paper presented by undergraduate Student member in District competition	$25 and certificate	Certificate

3. *Section*

$100 to be divided at the discretion of the Section, with a maximum of $50 for any one prize, and certificate for each winner.

4. *Branch (Undergraduate)*

Class	First Prize	Additional Prize
(a). Best paper	$10 and certificate plus an allowance of 13 cents per mile one way for 800 miles or less and 10 cents per mile one way for remaining distance to the District Student prize paper competition	Certificate

The complete rules for the award of prizes for AIEE technical papers appear in the September 1954 issue of *Electrical Engineering* (pages 825–6).

Conference on Magnetic Amplifiers Scheduled for April

The program for the Conference on Magnetic Amplifiers, cosponsored by AIEE Committee on Magnetic Amplifiers, IRE Professional Group on Industrial Electronics, and ISA Central New York Section, will consist of four half-day technical sessions and a manufacturers exhibit of magnetic amplifiers, components, and associated products.

The first technical session will consist of a group of invited papers by guest speakers who are well-known authorities in their respective fields. The other three sessions will be composed of papers chosen from those submitted to the Technical Program Committee in the form of a 200-word summary before December 21, 1955. Two copies of the papers chosen must be available at the conference in final form so that they can be published in the Report of the Special Technical Conference. Additional information can be obtained from Mr. C. F. Spitzer, General Electric Company, Building 3, Electronics Park, Syracuse, N. Y.

16 Honorary Degrees Bestowed by Polytechnic Institute

The Polytechnic Institute of Brooklyn, N. Y., climaxed the celebration of its Centennial anniversary by awarding 16 honorary degrees to industrial, scientific, and community leaders at a convocation.

The year-long Centennial celebration was marked under the theme "Science, Engineering, Research for Human Well Being." Forty scientific, engineering, and educational conferences were held during the celebration.

The honorary degree recipients were chosen on the basis of their accomplishments in a field of study offered at Polytechnic, or outstanding services to the community or Polytech. The list of honorary degree recipients included: Mervin J. Kelly (M '26, F '31), president of Bell Telephone Laboratories, N. Y., doctor of engineering degree; Philip Sporn (AM '20, M '26, F '30—*Edison Medalist* 1945), engineer and industrialist, president of American Gas and Electric Company, N. Y., doctor of engineering degree; Lloyd V. Berkner (AM '29, M '36, F '47), geophysicist and president of the Associated Universities, Inc., Brookhaven, N. Y., doctor of science degree; and Erich Hausmann (AM '06, M '13, F '18, Member for Life), engineer and dean emeritus of Polytechnic Institute, Brooklyn, N. Y., doctor of engineering degree.

Ohio Valley Section Installs Officers

Mr. J. C. Strasbourger, Vice President, District No. 11, AIEE, addressed the Ohio Valley Section on Institute Affairs at their September meeting at the Hotel Frederick, Huntington, W. Va. In addition to being the principal speaker, he assisted in the installation of the 1955–56 officers for the Section and the Scioto Valley Subsection. Seated Left to Right: R. W. Wagner, Section Vice-Chairman (1955–56); F. R. Willoughby, Section Secretary-Treasurer (1955–56); H. H. Kincaid, Section chairman (1955–56); C. H. McCann, Secretary-Treasurer—Subsection (1954–55). Standing Left to Right: J. C. Strasbourger, Vice-President AIEE District No. 11; H. P. Hagaman, Jr., Section Chairman (1954–55); W. M. Lewis, Jr., Subsection Chairman (1954–55); N. P. Bromley, Director (1955–56); E. J. Humphrey, Director (1955–56); J. M. Duncan, Subsection Secretary-Treasurer (1955–56); P. W. Meadows, Subsection Chairman (1955–56).

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Substations (*I. S. Mendenhall, Chairman; W. S. Scheering, Vice-Chairman;*

HONORED at Brooklyn Polytechnic Institute's Centennial, 16 scientific, industrial, and community leaders received honorary doctors degrees at the closing Centennial Convocation. (Left) P. Sporn, president of American Gas and Electric Company, receiving a degree from the hands of H. S. Rogers, president of the Institute. (Above) H. S. Rogers presenting degree to M. J. Kelly, president of the Bell Telephone Laboratories.

J. A. Smith, Secretary). The Committee on Substations held a round table discussion on the subject, "Future Trends in Substations," at the 1955 AIEE Fall General Meeting in Chicago, Ill. This meeting was attended by approximately 40 members of the committee and their guests.

One full day was spent discussing present and future practices of the various utilities; some comments were made by the representatives of the manufacturers on the committee concerning future developments in equipment. Many diverse opinions and practices were brought out, although there seemed to be definite trends along certain lines. Among the ideas that seemed to be indicative of the future were greater use of 3-phase reclosers, higher transmission and distribution voltages, and increased usage of 3-phase transformers rather than single phase. There also seems to be some trend toward the reduction of electrical clearances in line with the recommendations of an AIEE committee report, which was presented at the 1954 Winter General Meeting.

The Automatic and Supervisory Control Subcommittee has practically completed its work on the revision of C37.2-1945, "American Standard for Automatic Station Control, Supervisory and Associated Telemetering Equipment." It is expected that the fifth draft of this revision soon will be sent to the Standards Committee for their approval.

Committee on Insulated Conductors (*M. W. Ghen, Chairman; L. E. Fogg, Vice-Chairman; F. M. Hull, Secretary*). Work has been started at Princeton University, Princeton, N. J., on the 3-year project to study thermal characteristics of soils. It is expected that results of great value will be available to operators of underground cables and particularly pipe-type cables as this work progresses.

Work is advancing on a study of lightning protection of aerial cables which should result in greater protection for this type of equipment.

Science and Electronics Division

Committee on Magnetic Amplifiers (*W. J. Dornhoefer, Chairman; H. W. Lord, Vice-Chairman; A. B. Haines, Secretary*). In order to provide adequate representation of the rapidly expanding field of magnetic amplifiers, the committee has been increased from 22 to 31 members and several of the newly appointed members were present. The size of several of its subcommittees has also been increased.

This committee's Application Subcommittee sponsored a well-attended session at the 1955 National Electronics Conference at Chicago, Ill.

At present, the chief activity of the committee is directed toward a Special Technical Conference on Magnetic Amplifiers to be held in Syracuse, N. Y., on April 5–6, 1956. This conference will be under the joint sponsorship of the AIEE, Institute of Radio Engineers (IRE), and Instrument Society of America (ISA). The program will include both invited and contributed technical papers. An exhibit of pertinent devices and components will be held in conjunction with this conference.

"Meet the Engineer"

PHILADELPHIA SECTION MEMBERS were on the job when the Association for Computing Machinery (ACM) held its national meeting at the Penn-Sherwood Hotel, in Philadelphia, Pa., September 14–16. The Section sponsors a local radio program, "Meet the Engineer," broadcast over station WFLN. Program material is obtained from various engineering meetings, particularly those in which the electrical engineer has an interest. The small picture at upper left shows Dr. Morris Rubinoff (center), chairman of the local arrangements committee for the ACM meeting being interviewed by Philadelphia Section member T. H. MacCauley (right). Mr. MacCauley is chairman of the radio committee for "Meet the Engineer." At left is tape recorder engineer making a recording of the interview. Speeches made at the meeting were put on a tape and Mr. MacCauley is shown obtaining more details about a recorded address made by Dr. Rubinoff. The large picture was taken during one of three ACM luncheon talks.

First Student Branch Meeting

STUDENT BRANCH MEETING of Newark College of Engineering. C. Wheatley and A. Peldunas of Radio Corporation of America demonstrating transistorized equipment to M. Kiss, Student Branch chairman and other student members.

Electrical Techniques in Medicine and Biology (*T. H. Rogers, Chairman; H. P. Schwan, Vice-Chairman; W. S. Lusby, Secretary*). The committee continues, as one of its principal activities, to sponsor, jointly with Institute of Radio Engineers (IRE) and Instrument Society of America (ISA), the annual Technical Conferences on Electrical Techniques in Medicine and Biology. The Eighth Annual Conference was held in Washington on November 14–16, and included a very interesting and successful symposia on Angiocardiography, Audiology, and Instrumentation. These annual conferences are growing in significance in their role to provide a forum for engineers, physicists, biologists, and medical researchers to meet on common ground where each can contribute to the efforts of the others.

Future plans of the committee also include a session of papers at the AIEE 1956 Winter General Meeting on various health and hazard problems associated with electromagnetic radiation, and a report on a new device for X-ray image intensification.

At its last meeting, held in Chicago, Ill., on October 4, the committee decided to investigate the possible desirability of activity by the committee in the field of air pollution. An "ad hoc" subcommittee was appointed to look into this matter and report thereon at the forthcoming AIEE Winter General Meeting.

Committee on Electronics (*A. M. Zarem, Chairman; J. M. Cage* (Midwest), *H. L. Flowers* (Central), *H. M. Stearns* (West), *D. G. Wilson* (East), *Vice-Chairmen; J. A. Goetz, Secretary*). Committee activities were initiated this season with a successful dinner meeting at the AIEE Fall General Meeting in Chicago, Ill. The membership has been expanded to make the committee properly geographical in cross section, including the appointment of four sectional vice-chairmen.

A planning group was established by the chairman to formulate the present scope and function of committee activities and to plan for its future development. An initial meeting of this group will be held during the forthcoming AIEE Winter General Meeting in New York City. A dinner meeting of the full membership of the Committee on Electronics is also planned for the Winter General Meeting; time, date, and location to be announced later.

Subcommittee activities remain essentially unchanged from the last review. The Subcommittee on West Coast Activities has been eliminated as a result of the appointment of a committee vice-chairman representing that area.

Committee on Instruments and Measurements (*Ernst Weber, Chairman; C. F. Savage, Vice-Chairman* (East); *W. S. Pritchett, Vice-Chairman* (West); *P. K. McElroy, Secretary*). The direct committee membership has been reduced to the chairmen and vice-chairmen of the Group Subcommittees, and these in turn have been given nearly the autonomy of full-fledged technical committees in order to distribute the burden of papers review and session organization. In addition, several of the Group Subcommittees are organizing or cosponsoring special technical conferences, such as the National Telemetering Conference, Conference on Controlling and Recording Instruments, High Frequency Measurements Conference, Electronic Components Symposium, and Conference on Instrumentation in Medicine and Nucleonics.

Standardization activities have led to the completion of the new issue of the American Standard for Electrical Indicating Instruments, C-39.1-1955. The Master Test Code of Electrical Measurements in Power Circuits, cosponsored by the American Society of Mechanical Engineers, has now been approved by the Standards Committee. Both standards will be available in published form around the first of the year. Specifications for several electronic instruments have also been developed in co-operation with a corresponding subcommittee in the Institute of Radio Engineers. Work on definitions in American Standards Association C-42 is progressing.

The committee has again co-operated in the program of the Instrument Society of America in Los Angeles, held September 12–16, 1955.

Industry Division

Committee on Industrial Control (*L. H. Matthias, Chairman; J. W. Picking, Vice-Chairman; R. W. Moore, Secretary*). The Subcommittee on Test Codes, under the chairmanship of Mr. C. T. Evans, has completed and submitted to the main committee the second draft of a test code for "Procedures for Conducting Temperature Rise Tests, Resistors, Rheostats, and their Assemblies," and "Procedures for Conducting Continuous and Eight-Hour Temperature Rise Tests, A.C. and D.C. Controllers." Other sections of a test code for Industrial Control Equipment are being drafted by the subcommittee.

The Subcommittee on Electronic Control has completed a seventh draft of proposed "Standard for Electronic D.C. Motor Controllers," and plans to present this standard as a conference paper at the AIEE Winter General Meeting. W. H. Elliot, chairman of this Subcommittee, is actively promoting work on a photoelectric devices standard.

AIEE FELLOWS ELECTED

Board of Directors Meeting, October 6, 1955

Otto Robert Schurig* (AM '14, M '18), professor of engineering, Union College, Schenectady, N. Y., has been transferred to the grade of Fellow in AIEE "for contributions to increased knowledge and understanding in several areas of electrical engineering, particularly of the electromagnetic forces and temperature rises of buses and conductors carrying heavy currents." Mr. Schurig was born in Zwickau, Germany, May 7, 1890. He graduated from Harvard University and received a bachelor of arts degree, cum laude, in 1910; he obtained a bachelor of science degree in electrical engineering in 1911 from the Massachusetts Institute of Technology (MIT), and also did graduate work at MIT from 1913 to 1915, at Union College from 1925 to 1927, and again in 1946 to 1947. During the years 1911 to 1913, Mr. Schurig was employed with Stone and Webster Corporation and later with the Blackstone Valley Gas and Electric Company where he acquired experience in meter testing, power station operation, and electrical distribution circuit engineering problems. While doing graduate work at MIT in 1913, he accepted the position of instructor in the electrical engineering department and worked as an assistant in the Research Division. Later he became administrative assistant to the director, Electrical Engineering Research Division. In 1917, Mr. Schurig was an engineer in the consulting engineering laboratory of the General Electric Company. He began studies of the design and performance of d-c relays, including the development of control equipment for battery-operated navigation lights. He also began analytical studies relating to the appropriate design of switchgear components for electric transmission systems and the formulation of suitable application guides defining limiting application conditions. During the next 24 years he assumed responsibility for the planning, supervising, and development on electric components relating to switchgear, with particular emphasis on solving problems relative to unusual method measurements and heavy-current circuit conductors and their application. He was active in the determination of short-circuit currents in low-voltage systems, current-carrying capacities of conductors, and the application of silver as a contact material in electric circuits. In 1941, in the interest of National Defense, Mr. Schurig served as Administrative Officer of the Ballistic Research Laboratory, Army Ordnance Department, Aberdeen Proving Grounds, Md., and was elevated to the rank of colonel. In 1946 he was awarded the Certificate of Commendation and the Army Commendation Ribbon from the Ordnance Department for his outstanding performance of duty during the period 1941 to 1945. He returned to the General Electric Company engineering laboratory where he organized and supervised investigations and analytical studies to determine performance characteristics and design data relative to sea-water batteries. In 1947 he put into operation a security program for the general engineering laboratory; his operations were soon extended to include the Knolls Atomic Power Laboratory. Mr. Schurig also has been safety engineer and consultant on heavy-current engineering with the General Electric Company. The engineering consulting work on heavy-current conductor systems involved principally rendering technical assistance to different departments on such problems as temperature rise of conductors, electromagnetic forces due to current flow and the bracing required to withstand these forces, current division between multiple conductor elements in a-c operation, etc., He holds many patents for his inventions, and has contributed many articles to professional journals. Since September of this year, Mr. Schurig has been with the faculty of Union College as a professor of electrical engineering. He is a member of the Amer-

* Mr. Schurig's transfer to grade of Fellow was approved by the Board of Directors on August 17, 1955.

O. R. Schurig

D. E. Harnett

D. B. Smith

C. P. Stocker

ican Ordnance Association and the American Society for Safety Engineers.

Daniel Edward Harnett* (AM '26, M '38), engineer, General Electric Company, Syracuse, N. Y., has been transferred to the grade of Fellow in AIEE "for engineering leadership in peacetime and military radio design and for contributions to standardization in monochrome and color television." Mr. Harnett was born in Elmira, N. Y., July 20, 1899. He received a bachelor of arts degree from Columbia University in 1922, and an engineering degree from the same university in 1925. Mr. Harnett is an expert on synchronization systems for television. He is a radio and television circuit designer and has been in charge of large engineering groups working in this field. He has designed amplifiers for motion pictures, broadcast receivers and components, and the Sonora line of radio receivers and phonograph combinations. In 1929 he was appointed chief engineer for the Hazeltine Corporation and its subsidiaries. He was responsible for directing the firm's engineering staff and developed a wide variety of electronic equipment, which was important to the company's advancement in manufacturing radio and television receivers. During the years 1940 to 1941, he was a member of the first National Television System Committee (NTSC) which developed national standards for monochrome television. As chairman of the scanning panel, he presented the committee's recommendations in testimony before the Federal Communications Commission in 1941. In 1945 he formed the Harnett Electric Corporation for the design and manufacture of coils of many kinds. During WWII he was active in the development of IFF equipment (identification, friend or foe), which is a coded beacon technique used by the military to distinguish between friendly and unfriendly radars. He co-ordinated the efforts of a large number of companies in the manufacture of this type of equipment. In 1947 he was awarded the Certificate of Commendation by the United States Navy for his guidance in the development and coordination of production of a variety of identification and radar beacon equipments, which were used interchangeably in the Allied Services. Mr. Harnett, in 1948, designed television and sound broadcast receivers for the Emerson Radio and Phonograph Company, New York, N. Y. In 1950 he joined the General Electric Company, Syracuse, N. Y. That same year he was chairman of the panel on synchronization standards and a member of the co-ordination panel of the second NTSC, which developed the national color television standards now in effect. Mr. Harnett holds many patents for his design work in radio engineering. He has been working on advanced receiver development, including color television, since he joined the General Electric Company. He is a Fellow of the Institute of Radio Engineers and the Radio Club of America. Mr. Harnett served on AIEE's Television and Aural Broadcasting Systems Committee (1953–55).

* Mr. Harnett's transfer to grade of Fellow was approved by the Board of Directors on August 17, 1955.

David Beach Smith (AM '35, M '47), vice-president in charge of research, Philco Corporation, Philadelphia, Pa., has been transferred to the grade of Fellow in AIEE "for his work in establishing natural color television standards and for his contributions to the radio and television arts." Mr. Smith was born in Newton, N. J., December 3, 1911. He obtained a bachelor of science degree from the Massachusetts Institute of Technology in 1933, and a master of science degree in electrical engineering from the same institution in 1934. Mr. Smith's entire career has been with the Philco Corporation in Philadelphia, which he joined in 1934. At first he had a variety of assignments in the engineering and patent departments, including that of assisting the vice-president in charge of engineering. In 1941 he was made director of research and was given complete charge of research activities, including the administration of the Research Division of the engineering department. He was made vice-president in 1945 in charge of engineering for the corporation and wholly-owned subsidiaries. This position involved the complete responsibilities for technical affairs and the administration of the engineering department. The scope of products manufactured included radio receivers, phonographs, auto radios, television receivers, refrigerators, air conditioners electronic industrial equipment of different kinds including mobile communication equipment, television relay equipment, terminal equipment, etc. In 1948 he was made director. From 1936 to 1940 Mr. Smith was a member of the Radio Manufacturers Association Television Committee; from 1944 to 1948, chairman of the association's Television Systems Committee. During the year 1940 to 1941 he was chairman of the panel on polarization and a member of three other panels of the first National Television System Committee (NTSC) which developed standards for monochrome television. As chairman of the polarization panel, he presented its recommendations in testimony before the Federal Communications Commission in 1941. During the years 1951 to 1953 he was vice-chairman of the second NTSC, which developed color television standards; he also served as chairman of Panel 18, the co-ordinating group of NTSC; from 1950 to 1951 he was chairman of the Ad Hoc Committee on Color Television. Mr. Smith has done various committee work and has held a directorship with the Institute of Radio Engineers (IRE). From 1944 to 1946 he served as chairman of IRE's Philadelphia Section. In 1948 he was awarded the grade of Fellow in IRE. He served as vice-director of the Radio Television Manufacturers Association, engineering department, from 1950 to 1953. He was a consultant and member of the Signal Corps Research and Development Advisory Council from 1952 to 1954. Mr. Smith is a senior associate of the American Association for the Advancement of Science, and a member of Tau Beta Pi, Eta Kappa Nu, Franklin Institute, and the American Ordnance Association. From 1947 to 1948 he served on AIEE's Communication Committee.

Closman Paul Stocker (AM '39, M '45), president and general manager, Lorain Products Corporation, Lorain, Ohio, has been transferred to the grade of Fellow in AIEE "for his development of static ringing machines and dial tone generators." Mr. Stocker was born in Uhrichsville, Ohio, January 11, 1904. He obtained a bachelor of science degree in electrical engineering from Ohio University in 1926. He then joined the Bell Telephone Laboratories, New York, N. Y., as an engineer of research and development in the communication field. In 1932, he developed a number of his own inventions. One of these was the static-type telephone ringer as an industrial product. It was upon such patents that his present business was founded. In 1935, with an associate, he organized the Lorain Products Corporation and became its vice-president and chief engineer. Additional versions of the original ringing machines were introduced under his direction and accepted by the Independent Telephone Operators and Bell Telephone System. In 1947 Mr. Stocker became the company's president and general manager. Since that time and under his direction other equipment for independent telephone companies

as well as for the Western Electric Company, and the Bell System were developed. Notable among these are automatic battery chargers, selenium rectifiers, dial tone generators, power supplies, and other allied components and equipment for communication and the general industrial field. Mr. Stocker has patents in 26 foreign countries. He is past president of the Lake Erie Chapter of the Ohio Professional Engineers Society, and is a member of the Cleveland Engineering Society.

AIEE PERSONALITIES

H. P. Seelye (AM '19, F '43), manager of engineering for the Detroit (Mich.) Edison Company, has retired after 39 years of service with the company. A native of Marshall, Mich., he was first employed by Detroit Edison in 1907 in the customer's accounts department. He was graduated from the University of Michigan with a bachelor's degree in civil engineering in 1912. Re-employed at Detroit Edison in 1916, he worked in the distribution engineer's department before service in 1917–18 as a lieutenant in the U. S. Army Coast Artillery Corps. He rose through various positions in the company's Electrical Engineering Division to become chief engineer of the engineering department in 1949. He has been manager of engineering since 1952. A specialist in system engineering planning, he is the author of many books, among these: "The Economics of Electrical Distribution" and "Electrical Distribution Engineering." He is a regular contributor of articles to various journals of the electrical industry. He is active in the Edison Electric Institute, where he has served as chairman of several special committees, and is a member of the Engineering Society of Detroit. He was on the Domestic and Commercial Applications Committee of AIEE (1941–50).

J. B. Russell (AM '34, F '51), professor of electrical engineering and department head at Columbia University, New York, N. Y., has been appointed as a full-time consultant by the Electronics Division of the General Electric Company. He is now a member of the engineering staff of the electronics laboratory, located in Syracuse, N. Y., and is working on the application of the new magnetic and dielectric materials, as well as in the general field of electronics. Dr. Russell received all his technical education at the Massachusetts Institute of Technology and spent 3 years on the academic staff there. He moved to the electrical engineering department of Columbia University in 1931. For 5 years during World War II he was engaged in supervising research and development work in the field of fire control, first as a technical aide to the National Defense Research Committee and then as expert consultant in the Office of the Secretary of War. He is a Fellow of the New York Academy of Sciences, a senior member of the Institute of Radio Engineers, a member of the Association for Computing Machinery and the American Society for Engineering Education. Mr. Russell has served on the following committees of the Institute: Standards (1939–50); Communication (1941–49); Basic Sciences (1947–49); Instruments and Measurements (1948–49); Industrial Control (1948–49); Feedback Control Systems (1949–50); and liaison representative, Standards Committee (1951–54).

F. D. Troxel (AM '26, F '50), partner and senior electrical engineer, Vern E. Alden Company, engineers, Chicago, Ill., has resigned from the company but will continue in the capacity of consulting engineer. He has moved his permanent residence to Phoenix, Ariz. He has been doing consulting work in the Chicago area for 33 years. Mr. Troxel has served on the Power Generation Committee of AIEE (1943–45).

J. G. Stephenson (AM '42, M '48), engineer, Airborne Instruments Laboratory, Inc., Mineola, N. Y., has been promoted to assistant supervising engineer of the applied electronics section of the Research and Engineering Division. Mr. Stephenson graduated from Yale University with a bachelor's degree in 1939 and from Stanford University in 1941 with the engineer degree. Prior to his employment with Airborne Instruments Laboratory in 1945, Mr. Stephenson was a research associate at the Radio Research Laboratory of Harvard University, where he worked on radar countermeasures. He also served with the American-British Laboratory in England and was a technical observer in the Mediterranean area. In the 10 years of his employment with Airborne Instruments Laboratory, he has been associated with major developments in the fields of uhf receivers, stable oscillators, and data-processing equipment.

Bartow Van Ness, Jr. (AM '23, F '47), chief engineer, **C. W. Watchorn** (AM '29, M '48), efficiency engineer, and **C. H. Rahe** (AM '52, M '55), senior electrical engineer, all of Pennsylvania Water and Power Company, have joined the Pennsylvania Power and Light Company's engineering staff as a result of the recent merger with Pennsylvania Water. Mr. Van Ness has been appointed to the newly created position of assistant mechanical engineer in the mechanical engineering department; Mr. Watchorn is development engineer in the system planning department; and Mr. Rahe has become generating station engineer in the electrical engineering department. Mr. Van Ness is a native of Omaha, Nebr. After receiving a bachelor's degree in engineering from Johns Hopkins University and a master's degree in electrical engineering from Massachusetts Institute of Technology, he joined Pennsylvania Water in 1922 as assistant to the test engineer. Following promotions to electrical engineer, assistant to the chief engineer, and assistant advisory engineer, he became chief engineer in 1952. He also held, simultaneously, top supervisory positions with Safe Harbor Water Power Corporation, including that of chief engineer since 1942. He has been on the following AIEE Committees: Electrical Machinery (1938–46), Special Committee on Bargaining and Related Matters (1945–48), and Board of Examiners (1950–55). He is a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Standards Association, and the Pennsylvania Electric Association. For many years he has been an active member of national society engineering committees, having served as chairman of the electrical equipment committee of Edison Electric Institute. Mr. Watchorn, a native of Waltham, Mass., received bachelor of science and electrical engineering degrees from Worcester Polytechnic Institute and later, while working for Pennsylvania Water, was awarded a bachelor of laws degree from the University of Maryland Law School. He joined Pennsylvania Water in 1924 as test engineer after service with General Electric Company and New York Edison Company. He also held the position of assistant to the general superintendent prior to being named efficiency engineer. He is a member of Tau Beta Pi and Sigma Xi. Mr. Rahe, a native of Baltimore, Md., had been electrical engineer of Pennsylvania Water since joining the utility in 1937, following service with the Chevrolet Division of General Motors Corporation in Baltimore. He was graduated from the University of Maryland with an electrical engineering degree and is a member of Tau Beta Pi and the electrical equipment committee of the Pennsylvania Electric Association.

H. S. Osborne (AM '10, F '21, Member for Life), retired president, American Telephone and Telegraph Company, New York, N. Y. and past president of the International Electrotechnical Commission, Montclair, N. J., received the Howard Coonley Medal for "service in advancing the national economy through voluntary standards." The gold medal was presented at an award dinner October 25, during the Sixth National Conference on Standards at the Sheraton-Park Hotel in Washington, D. C. The 3-day conference was sponsored jointly by the American Standards Association and the National Bureau of Standards. Mr. Osborn has been very active in AIEE committee work. (For a complete listing of this service see page 1018 of the November 1955, *Electrical Engineering*.)

T. E. Palmer (M '50), sales engineer, S&C Electric Company, Chicago, Ill., has been appointed to serve the entire state of Ohio for the company. **G. C. Pappas** (AM '52), also sales engineer for S&C, has moved from Chicago to Indianapolis, Ind. He now serves the Indiana and Kentucky territory.

David L. Johnson (AM '49), assistant professor of electrical engineering at Oklahoma A. & M., has been appointed professor and head of the electrical engineering department at Louisiana Polytechnic Institute, Ruston, La. He served as AIEE Branch

Counselor from 1949–1955. He was chairman of the 7th District Student Activities Committee, 1952–53; Program Committee, Fall General Meeting, 1950; Working Committee, Electrical Conference for the Petroleum Industry, 1954. He is a member of Phi Kappa Phi, Tau Beta Pi, Eta Kappa Nu, Sigma Tau, Sigma Xi (Associate), and Pi Mu Epsilon.

OBITUARIES

Edward L. Nelson (AM '20, M '26), scientific chief of research and development Army Signal Corps, Washington, D. C., died September 21. Mr. Nelson was born in Warsaw, Ind., 1891. He was well-known in the communications industry. He graduated from Armour Institute of Technology, Chicago, Ill., and in 1917 joined the engineering staff of the Western Electric Company. During World War I, he was in England as a radio-telephone specialist on anti-submarine devices and as radiotelephone officer with naval headquarters in London. In 1921 he joined the Bell Telephone Laboratories as supervisory engineer. He later became radio development engineer and was responsible for the design and development of commercial radio transmitting and receiving equipment. During World War II, he was in charge of many military radio and radar projects of the Bell Laboratories for both the U. S. Army and Navy. He was also responsible, after World War II, for the design and development of equipment for Bell System's mobile radiotelephone service. He was a Fellow in the Institute of Radio Engineers, and a member of the Institute of Navigation.

Thomas J. Little (M '45), retired Eastern vice-president of the Pyle-National Company of Chicago, Ill., died recently. He was formerly the Eastern sales manager for the company in New York, N. Y. Mr. Little was born in Virginia City, Nev., 1892. He graduated from Union College, Schenectady, N. Y., and was an electrical engineer for many years with the Anaconda Company and its subsidiary, the Anaconda Wire and Cable Company, New York, N. Y. During World War II, he was a consulting engineer for the New York Ordnance District and received an Award of Merit from the War Department. In 1945 and 1946 he also served with the Metals Group of the Military Government in Germany.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of October 20, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Agin, J., engineer, Radio Corporation of America, Camden, N. J.

Allen, J. S., transformer specialist, International General Electric Co., New York, N. Y.

Andrew, E. H., Jr., assistant professor, electrical engineering, Texas A & M College, College Station, Tex.

Barnum, W. L., electrical engineer, U. S. Bureau of Reclamation, Yuma, Ariz.

Bishop, C. K., electrical engineer, Acro Manufacturing Co., Columbus, Ohio

Blefary, F. F., member of technical staff, Bell Telephone Laboratories, New York, N. Y.

Boone, C. C., electrical engineer, Ebasco Services, Inc., New York, N. Y.

Booth, R. C., chief engineer, Electric Eye Equipment Co., Danville, Ill.

Bossman, L. J., works engineer, ac spark plug division, General Motors Corp., Milwaukee, Wis.

Braly, R. E., assistant engineer, Baltimore Gas & Electric Co., Baltimore, Md.

Bubenko, J. A., consulting engineer, Swedish State Power Board, Stockholm, Sweden

Cammarata, J., department head, research and development section, Arma Div., American Bosch Arma Corp., Garden City, N. Y.

Cataldo, J. B., director of research and development, Bull Dog Electric Products Co., Detroit, Mich.

Chapman, C. R., assistant professor, electrical engineering, Purdue University, Lafayette, Ind.

Clark, J. R., design engineer, General Electric Co., Fort Wayne, Ind.

Conklin, J. S., project engineer, Servomechanisms, Inc., El Segundo, Calif.

Crenshaw, R. M., application engineer, General Electric Co., San Francisco, Calif.

Cunningham, G. W., electrical engineer, U. S. Corps of Engineers, Walla Walla, Wash.

Daniels, H. A., assistant electrical engineer, Crown Zellerbach Corp., West Linn, Ore.

DeByle, W. C., telephone equipment engineer, Western Electric Co., Chicago, Ill.

DeRemer, K. R., electrical engineer, Victor Div., Radio Corporation of America, Harrison, N. J.

DesRoberts, H. J., owner, DesRoberts Electrical Co., Lynn, Mass.

Edgell, E. E., engineer, Westinghouse Electric Corp., Buffalo, N. Y.

Fenrick, M. J., electrical superintendent, Abitibi Power & Paper Co., Ltd., Sault Ste. Marie, Ont., Canada

Flugum, R. W., consulting and application engineer, Westinghouse Electric Corp., Milwaukee, Wis.

Fox, E. R., engineer, Westinghouse Electric Corp., Baltimore, Md.

Frumhoff, E. L., chief electrical engineer, Daniel, Mann, Johnson & Mendenhall, 4201 Sunset Blvd., Los Angeles, Calif.

Googin, T. M., electrical engineer, Consolidated Purchasing & Designing, Inc., San Francisco, Calif.

Hale, C. J., process engineer, General Electric Co., Richland, Wash.

Hudgings, D. W., design and development engineer, Radio Corporation of America, Camden, N. J.

Johansen, K. D., group engineer, dynamics staff, Boeing Airplane Co., Seattle, Wash.

Jones, F. D., senior engineer, Control Engineering Corp., Norwood, Mass.

Laone, E. T., commercial manager, Chesapeake & Potomac Tel. Co., Baltimore, Md.

LeDoux, J. M., district manager, National Electric Products Corp., New Orleans, La.

Mahmoud, M. A., utilities general supervisor, Societe Egyptienne d'Engrais Et d'Industries Chimiques, Suez, Egypt

Marston, M. R., Jr., electrical engineer, General Electric Co., San Diego, Calif.

Maynard, C. A., vice-president, research and engineering, The Indiana Steel Products Co., Valparaiso, Ind.

McCullough, J. R., operations engineer, Ontario Hydro Electric Power Commission, Niagara Falls, Ont., Canada

Mekelburg, L. J., drafting unit leader, Square-D Co., Milwaukee, Wis.

Menke, E. M., assistant professor, electrical engineering, University of Nevada, Reno, Nev.

Milde, N. H., supervisor, instruments, Northrop Aircraft, Inc., Hawthorne, Calif.

Moran, R. E., electrical engineer, Chas. T. Main, Inc., Boston, Mass.

Morrison, C., planning engineer, The Potomac Edison Co., Hagerstown, Md.

Mutschler, W. H., Jr., assistant central station engineer, Allis-Chalmers Mfg. Co., Pittsburgh, Pa.

Nettesheim, H. F., associate professor and chairman, electrical engineering department, University of Santa Clara, Calif.

Nolte, R. E., associate professor, electrical engineering, Missouri School of Mines & Metallurgy, Rolla, Mo.

Olsen, O. F., staff engineer, Grumman Aircraft Engineering Corp., Bethpage, N. Y.

Orecchia, G., engineer, MEGALUX, Turin, Italy

Pester, R. F., development engineer, General Electric Co., Schenectady, N. Y.

Pettit, D. L., supervising design engineer, Square-D Co., Milwaukee, Wis.

Pharr, J. C., project superintendent, Reynolds Electrical & Engineering Co., Inc., Los Alamos, N. Mex.

Prescott, R. D., owner, Elite Drafting Service, Yonkers, N. Y.

Price, B. E., sales manager, National Electric Coil Co., Columbus, Ohio

Purcell, J. O., engineer, Electricity Supply Board, Dublin, Ireland

Reynolds, H. F., director, utilities div., DPW., 9th Naval District, Great Lakes, Ill.

Rich, R., consulting electrical engineer, 2686 W. Broadway, Vancouver, B. C., Canada

Robins, M., consulting electrical engineer, Robins Engineering Co., New Haven, Conn.

Sandlin, J. L., vice-president and sales manager, Priester Supply Co., Inc., Dallas, Tex.

Saunders, H. O., Jr., engineer, American Tel. & Tel. Co., New York, N. Y.

Schultz, R. B., field engineer, Elliott Co., New York, N. Y.

Schwan, H. P., associate professor, electrical engineering, Moore School of Electrical Engineering, Philadelphia, Pa.

Seschachar, K. V., electrical engineer, The Tata Iron & Steel Co., Ltd., Jamshedpur, India

Smith, E. H., partner, Smith & Strain, EE, 3158 Maple Dr., N. E., Atlanta, Ga.

Spencer, J. E., transmission engineer, Southern Bell Tel. & Tel. Co., Birmingham, Ala.

Steward, H. R., assistant supervisor of electrical tests, Pennsylvania Power & Light Co., Hazleton, Pa.

Stewart, R. L., head meter and relay departments, Grand River Dam Authority, Pryor, Okla.

Stoddard, H. G., substation design engineer, Texas Power & Light Co., Dallas, Tex.

Strong, G. H., electrical engineer, General Electric Co., Richland, Wash.

Tipton, L. C., Jr., relay and general test field engineer, Tennessee Valley Authority, Knoxville, Tenn.

Winter, J. H., Jr., assistant engineer, Baltimore Gas & Electric Co., Baltimore, Md.

Wolsencroft, E., district manager, English Electric Co. of Canada, Vancouver, B. C., Canada

Woody, E. W., system supervising control engineer, Appalachian Electric Power Co., Roanoke, Va.

72 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before December 25, 1955, or February 25, 1956, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Altekruse, J. L., Goodyear Aircraft Corp., Akron, Ohio

Babin, R. S., Anderson-Nichols & Co., Boston, Mass.

Bailey, H. T., Brillion Iron Works, Inc., Brillion, Wis.

Bales, C. A., U. S. Steel Corp., Gary Ind.

Bansal, D. R., Punjab Engineering College, Chandigarh, India

Blake, W. R., Western Switchboard Co., San Francisco, Calif.

Bodle, D. W., Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Bryan, J. M., Humble Oil & Refining Co., Baytown, Tex.

Cheng, D. K., Syracuse University, Syracuse, N. Y.

Cleworth, C. W., Cleworth Publishing Co., Inc., Textile Age Inc., Special Equipment Co., Cos Cob, Conn.

Cochran, D. H., E. I. du Pont de Nemours Co., Wilmington, Del.

Endres, R. O., RCA Engg. Products Div., Camden, N. J.

Enslein, K., Cyclotron Lab., University of Rochester, Rochester, N. Y.

Gheith, F., Egyptian Republic Telegraphs & Telephones, Cairo, Egypt

Grim, J. P., Jr., Sarawak Oilfields Ltd., Lutong, Sarawak, Br. Borneo

Hawkes, H. D., Elliott Brothers (London) Ltd., Borehamwood, Hertfordshire, England

Heikkila, F. E., Westinghouse Electric Corp., Lima, Ohio

Jackson, N. P., Atomic Products Div., General Electric Co., Washington, D. C.

Lowry, F. W., Westinghouse Electric Corp., Lima, Ohio

Magruder, C. C., Kaiser Aluminum & Chemical Corp., Mead, Wash.

Morin, J. R., Sylvania Electric Products Inc., Danvers, Mass.

Quinlan, L. L., Inland Steel Co., East Chicago, Ind.

Rhodes, A. E., Atomic Energy Commission, Los Alamos, N. Mex.

Schenk, H. M., Stackpole Carbon Co., St. Marys, Pa.

Schwabe, W. E., National Carbon Co., Niagara Falls, N. Y.

Scott, J. B., Standard Telephone & Cables Pty. Ltd., Sydney, N. S. W., Australia

Sealander, B. E., Republic Aviation Corp., Farmingdale, L. I., N. Y.

Shea, R. F., General Electric Co., Schenectady, N. Y.

Taylor, D. G., Gardner Electric Mfg. Co., Emeryville, Calif.

Thanos, P. P., Inland Steel Co., East Chicago, Ind.

Van der Spek, J. H., Syndicat d'Etude de l'Energie Nucleaire, Brussels, Belgium

Wampach, R. G., Teletype Corp., Chicago, Ill.

Weinachel, B. O., Weinachel Engineering Co., Inc., Kensington, Md.

33 to grade of Member

OF CURRENT INTEREST

U.S.S. FORRESTAL, equipped with TACAN, new ultrahigh-frequency radio system, showing locations of antennas (circled) on deck corner, and of radio beacon (circled) on mast.

New Radio System and TACAN Provide Instant Contact between Carrier and Planes

THE LAUNCHING of the supercarrier *U.S.S. Forrestal* at Newport News, Va., introduced a new advance in naval communications systems. Backbone of the ship's communications is a long-range, ultrahigh-frequency radio system which provides a vital "lifeline" between the 60,000-ton vessel and its fleet of approximately 90 aircraft.

Developed by Federal Telecommunications Laboratories (FTL), division of International Telephone and Telegraph Corporation, the system is designed to meet the extremely high reliability and performance standards set by the United States Navy which sponsored the project. Other FTL developed electronic aids aboard the sleek 1,036-foot carrier include the TACAN (tactical aircraft navigation) radio beacon, heart of the aircraft guidance equipment of the vessel for tactical air navigation, a system developed for the United States Navy and the United States Army Air Force to pinpoint aircraft position, and related communications devices.

As modern in concept as the ship's flight deck, the *Forrestal*'s uhf radio gear is capable of providing the dependable, trigger-like communications demanded by its jet fighter planes. The system has an effective range of $1\frac{1}{2}$ times that of other equipment, and can operate at altitudes flown by the fastest modern jet aircraft.

The most recent techniques in radio communications have been incorporated, including a unique antenna array that provides full 360-degree coverage. The location of the eight antennas on the deck corners and the gun tubs of the flight deck helps to eliminate interference from reflections off the superstructure.

The Bureau of Ships and the United States Navy, as well as FTL engineers worked to overcome one of the principal bottlenecks, that of interference from other antennas, ship superstructure, and reflections from the sea. In the system on board the *Forrestal*, special design features have made possible the installation of antennas with 180-degree coverage at deck corners where they are absolutely free from interfering objects. Instantly available radio communication between the carrier and its air arm is provided by powerful new uhf electronic aids. Even with the antennas at half their former height, the new system can provide a much greater communication range than its World War II counterpart.

The ultrahigh-frequency sector array type system aboard the *Forrestal* was first installed on the aircraft carrier *U.S.S. Lake Champlain* in June 1954, as a 4-antenna system. The TACAN system provides constant automatic distance and bearing indications on a meter which gives the informations in nautical miles and enables the pilot to fix his position on a chart.

New York First State to Have Workers' Radiation Protection Code

REGULATIONS TO PROTECT workers in NewYork State from on-the-job hazards of atomic energy and other radiation have been adopted by the Board of Standards and Appeals and will become effective on December 15. The new regulations, to be enforced by the safety and industrial hygiene staffs of the New York State Department of Labor, are Industrial Code Rule No. 38.

New York is the first state in the nation to have a comprehensive State safety code in complete conformity with recent Atomic Energy Commission safety regulations. Rear Admiral William S. Maxwell (United States Navy, retired), chairman of the Board of Standards and Appeals, declared: "Approximately 150,000 New York State workers are employed in industries where exposure to the effects of industrial radiation is possible. The rule, as adopted, covers all phases of the field, including the industrial use of isotopes."

The adoption of the code is the culmination of a 2-year study by a 26-man Labor Department advisory committee, composed of labor, management, medical, scientific, and Government representatives. The code went through 12 different drafts before being considered by the Board, and was the subject of 7 public hearings before that body preceding final adoption.

The New York State Health Department recently adopted regulations in its Sanitary Code covering protection of personnel in hospitals, dental offices, and similar establishments. The two codes will complement each other, thus, covering most peacetime uses of radiation.

Significant provisions of the code are contained in sections on registration, control of exposure, dose limits, installation surveys, keeping of records, personnel monitoring, caution labels, and signs.

Major Code Requirements

All installations and mobile services are to be registered. This will enable the Labor Department to have knowledge of the location, type, degree of hazard, and ownership of every radiation source in New York State. Existing installations must be registered by March 15, 1956.

Each radiation installation must have a radiation safety supervisor and a radiation safety officer who is designated by the owner. Workers exposed to any radiation must be trained by a supervisor and be completely informed of hazards in the installations. Minors under 18 will not be permitted to to work in areas of possible hazard.

The owner of an installation is given the option of two methods of determining dose limits—on a weekly basis or on a quarter-year dose limit basis. When a person is exposed to greater than the specified limits, the employer shall report the facts to the Commissioner. The rule takes effect where any employee may be exposed to one-tenth of the permissible doses as set forth in Code Rule No. 38.

The radiation officer will be required to make a survey evaluating the hazard when conditions in the installations change, or more often when necessary. Proper detecting and measuring instruments must be readily available.

Any employee who in any way receives 25 per cent or more of the radiation dose limit must be supplied with and must use appropriate personnel monitoring equipment. These may be dosimeters or film badges or other similar devices.

The code also sets up a requirement for precaution signs or labelling which must contain the standard radiation symbols, as specified in the code, and appropriate cautionary wording.

The table of weekly permissible limits is as follows:

(1) Entire body exposure: 300 mrem (milliroentgens equivalent mammal—a measure of radiation amount and relative effect on living tissue) in the blood-forming organs, gonads, and lens of the two eyes; 600 mrem in the skin.
(2) Entire body exposed and low penetrating power: 300 mrem in lens of the eye, 1,500 mrem in any other part of the body.
(3) Hands and forearms exposed only, 1,500 mrem in the skin area.
(4) Feet and ankles—1,500 mrem.
(5) Hand and neck only, 1,500 mrem skin area: 300 mrem around eyes.
(6) Inhaled or ingested radiation and direct exposure to rays together must not exceed appropriate limits per week.

Future Meetings of Other Societies

American Society of Refrigerating Engineers, Annual Meeting. December 1–3, Traymore Hotel, Atlantic City, N. J.

American Society of Agricultural Engineers, Winter Meeting, December 4–7, Edgewater Beach Hotel, Chicago, Ill.

Agricultural Ammonia Institute, Annual Meeting, December 5–7, Hotel Muehlebach, Kansas City, Mo.

Exposition of Chemical Industries, December 5–9, Commercial Museum and Convention Hall, Philadelphia, Pa.

The Society of the Plastics Industry, Inc., Conference of Film, Sheeting, and Coated Fabrics Division, December 6–7, Hotel Commodore, New York, N. Y.

American Society of Agricultural Engineers, Winter Meeting, December 11–14, Edgewater Beach Hotel, Chicago, Ill.

American Society of Refrigeration Engineers, 51st Annual Meeting, The Traymore, Atlantic City, N. J.

American Pharmaceutical Manufacturers Association, Midyear Meeting, December 12–14, Waldorf Astoria Hotel, New York, N. Y.

Nuclear Congress and Atomic Exposition, Sponsored by Engineers Joint Council and A.I.Ch.E., December 12–17, Public Auditorium, Cleveland, Ohio

American Chemical Society, Pittsburgh Award Meeting, December 15, Pittsburgh, Pa.

Acoustical Society of America, December 15–17, Brown University, Providence, R. I.

19th Wright Brothers Lecture, United States Chamber of Commerce Building Auditorium, December 17, Washington, D. C.

American Association for the Advancement of Science, 122nd Annual Meeting, December 26–31, Atlanta, Ga.

American Physical Society, December 28–30, University of Southern California, Los Angeles, Calif.

National Science Foundation Conference, Low-Temperature Physics and Chemistry, December 28–30, Louisiana State University, Baton Rouge, La.

American Chemical Society, Annual Christmas Symposium, Division of Industrial and Engineering Chemistry, December 29–30, Princeton University, Princeton, N. J.

Hydraulic Institute, January 8–10, 1956, Terrace Plaza Hotel, Cincinnati, Ohio

Second National Symposium on Reliability and Quality Control in Electronics, sponsored by Institute of Radio Engineers, January 9–10, Hotel Statler, Washington, D. C.

Compressed Air and Gas Institute, January 16–18, Grand Hotel, Point Clear, Ala.

Conference on the Practical Utilization of Recorded Knowledge, present and future, January 16–18, The School of Library Science, Documentation and Communication Research Center, Western Reserve University, Cleveland, Ohio.

American Society of Heating and Air Conditioning Engineers, Inc., Annual Meeting, January 23–25, Cincinnati, Ohio.

National Rural Electric Co-operative Association, 14th Annual Meeting, January 23–26, St. Louis, Mo.

American Management Association, General Management Conference, January 24–27, Fairmont Hotel, San Francisco, Calif.

Insulation Contributes to Efficiency of Ohio Valley Electric Corporation Plants

CONSERVATION OF FUEL under operating temperatures sometimes exceeding 1,000 F is a challenging requirement in two Ohio River steam-electric generating plants now nearing completion.

The Ohio Valley Electric Corporation (OVEC), and its subsidiary, Indiana-Kentucky Electric Corporation (IKEC), were organized in 1952 by 15 private electric utility companies to build, operate, and maintain the necessary generation and transmission facilities to supply the required power for a diffusion installation.

The plants, together costing $325 million, are Clifty Creek Station, at Madison, Ind., and Kyger Creek Station, near Cheshire, Ohio, constructed to furnish power needs of the Atomic Energy Commission's (AEC) new $1.15 billion uranium diffusion plant near Portsmouth, Ohio.

Extensive use of thermal insulation help make the Ohio and Indiana facilities the nation's most economical and efficient power generating stations.

The Kyger Creek plant with a capacity of 1.075 million kw and the Clifty Creek facility of 1.29 million kw are scheduled to be finished in early 1956. Kyger Creek has five turbo-generating units of 215,000 kw each, and Clifty Creek has six 215,000-kw units. Both plants have been in operation, delivering power to the AEC, since last January. They are the two largest power plants ever built by private enterprise.

The Portsmouth uranium diffusion center was built by the United States Atomic Energy Commission to produce U-235 for atomic defense weapons.

Fiberglas and Kaylo insulations, both supplied by Owens-Corning Fiberglas Corporation of Toledo, Ohio, are being applied on pipes, breechings, boilers, and ducts to conserve heat and protect operating personnel.

The $4 million insulation contract placed with North Brothers of Atlanta, Ga., is believed to be the largest single insulation order in the electrical industry's history. The Babcock & Wilcox Company, New York has the boiler contract.

Each of the eleven 215,000-kw turbo-generating units is cross-compound in design,

SECTION OF KYGER CREEK PLANT (top left) being constructed at Cheshire, Ohio, to supply electric power to the atomic production center, Portsmouth, Ohio, shows three hot gas flues being covered with Kaylo insulation. (Bottom left) Heavy elastic fibered coating being sprayed over glass fabric reinforcement on special duct insulation of breeching at Kyger Creek Station. (Above) Recirculating gas and flue ducts at Kyger Creek finished with mineral wool cement placed over the sprayed Kaylo insulation.

operating off a single boiler. Steam entering the high-pressure side of the unit is superheated to 1,050 degrees Fahrenheit and reheated to the same temperature before entering the low-pressure side. Pressure of the steam entering the high-pressure side is 2,000 pounds per square inch.

Annually, about 7 million tons of coal will be consumed by the two facilities. This amount could heat more than half the homes in Ohio for a year.

Sponsoring companies are: Appalachian Electric Power, Cincinnati Gas and Electric, Columbus and Southern Ohio Electric, Dayton Power and Light, Indiana and Michigan Electric, Kentucky Utilities, Louisville Gas and Electric, Monongahela Power, Ohio Edison, Ohio Power, Pennsylvania Power, Potomac Edison, Southern Indiana Gas and Electric, Toledo Edison, and West Penn Power, the 15 companies which joined to form OVEC.

Atomic Particle Discovered by AEC and University of California

DISCOVERY OF A NEW ATOMIC particle, the anti-proton, which may inaugurate a new era of nuclear research was announced jointly by the University of California and the Atomic Energy Commission. (AEC).

The anti-proton (sometimes called the negative proton), a nuclear ghost which has haunted the world's physicists for a generation, was created from energy generated in the Berkeley bevatron—the most powerful atom-smasher in the world.

Identification of the particle in one of the classical experiments of nuclear physics was achieved by a team of radiation laboratory physicists—Drs. Owen Chamberlain, Emilio Segre, Clyde Wiegand, and Thomas Ypsilantis—with the help of Herbert Steiner and the all-important co-operation of Dr. Edward J. Lofgren, physicist in charge of the bevatron. The anti-proton was first observed on September 21, and the experiment was fully confirmed on October 17.

Dr. Lawrence, inventor of the cyclotron and Nobel prize winner, stated that discovery of the anti-proton fulfilled one of the important purposes for which the AEC spent some $9.5 million in bevatron construction costs plus annual research budgets. The radiation laboratory conducted one of the major fundamental research programs for the AEC since that agency was established.

The discovery is a major fundamental achievement in physics although it is not possible now to evaluate it fully.

"Recalling that at the beginning of the past quarter century the discovery of the positive electron set off the remarkable developments in nuclear physics that followed," Dr. Lawrence said, "one cannot help but wonder whether the discovery of the anti-proton . . . likewise is a milestone on the road to a whole new realm of discoveries in high-energy physics that are to come in the days or years ahead."

There is no known "practical" application of the anti-proton. Nor is there any known way in which the anti-proton could be used to generate energy as the neutron does in fission. The anti-proton is a heavy particle of the same mass but of opposite charge from the proton, which is one of the basic particles found in all atomic nuclei.

The existence of anti-protons has been a basic tenet of generally accepted atomic theory for a quarter of a century. Despite continuing experiments with cosmic rays, the particle had not been detected.

The discovery does not modify the model of the atomic nucleus, according to the discoverers. Rather it reinforces and solidifies

current theory. This elimination of uncertainty about one of the cornerstones of nuclear theory is one of the discovery's most valuable features.

The Berkeley scientists pointed out that the anti-proton does not exist in the atomic nucleus, which is composed of only protons and neutrons. Anti-protons are born and "live" only outside the nucleus following some high-energy nuclear event similar to the collision resulting from bevatron bombardment. The main reason anti-protons have not been discovered before is that they occur only at high energy.

Until the bevatron was constructed nuclear bombardment of sufficient energy could not be made. The reaction is as follows: protons are accelerated in the bevatron to 6.2 billion electron volts. These particles are directed at a target of copper inside the bevatron chamber. When the proton crashes into a neutron in one of the copper atoms, out of the collision come the two original particles (the proton projectile and the struck neutron); and a brand new set of heavy particles a proton and an anti-proton. In the collision, a part of the bombarding proton energy is converted into mass according to Einstein's theory. The particles are expected to be found in cosmic rays but in low abundance.

The anti-proton is stable in a vacuum and does not disintegrate spontaneously. When, however, it comes into contact with the proton the two particles immediately decay into mesons and disappear. Essentially, the scientists demonstrated the anti-proton by devising selecting apparatus constituting a "maze" through which only anti-protons could pass. To date, the particles have been observed only by radiation counters. Efforts are being made to obtain photographs of them in photo-emulsions.

First Electronic Range Offered by Tappan Stove to Average Consumer

AN ELECTRONIC RANGE—most revolutionary development in home cooking since introduction of electricity—has become a reality for the American housewife with offer of the first production models available to the nation's consumers by The Tappan Stove Company.

Company development engineers and home economists demonstrated three of the ranges which have been field tested for more than a year in a number of homes on a three-meal-a-day basis and which can bake a cake in six minutes in a cold oven.

Improvements suggested by the home users, as well as advances made in the research laboratory and test kitchen were utilized in the built-in model put on the market.

The new oven is almost 10 times faster than conventional ovens, being capable of baking a potato in 5 minutes. Bacon can be broiled on a paper plate with a paper napkin crumpled beneath it to absorb the excess grease drippings. The new oven offers greater flexibility in cooking foods formerly prepared on surface units. A selection of high- or low-speed cooking is made and a timer is set according to the need of the food to be prepared. The electronic range timer is calibrated in seconds for the first three minutes, and the range automatically shuts off when cooking is completed.

It was found that the electronic range had many advantages not found in conventional gas and electric models beside the 1/10th to 1/2 reduction in cooking time. Less dishes are needed inasmuch as food can be cooked in the glass or china serving dish which remains cool thus preventing food from sticking. Therefore, hand dish washing is made easier and all dishes washed in automatic dishwashers need no scrapping. Pots and pans are virtually eliminated. There is no heat in the kitchen, oven walls remain cool and can be wiped clean by using a damp cloth.

The microwave unit used to cook the food was developed in conjunction with the Raytheon Manufacturing Company.

The built-in model weighs 150 pounds, has two sets of controls for the speed and timer settings, and is aluminum lined. The electronic unit will not operate unless the door is latched. Thus, users cannot come in contact with the microwaves.

Because the electronic range transmits microwaves, the Federal Communications Commission assigned a frequency of 2,400 megacycles to the cooking unit. The range will not interfere with reception either on radio or television sets.

A 220-volt electric current using the same type of outlet and cable as an electric range operates the electronic range with no special installation or plumbing. Cost of operation is less than that of conventional ranges test users have found.

FIRST ELECTRONIC RANGE comes off The Tappan Stove Company assembly line after 4½ years development and 1½ year field test.

Signal Corps Develops Miniature Magnetron Tube

The world's smallest continuous-wave, self-contained magnetron tube—a must for developing small mobile radar sets that can be carried by troops in fox holes to warn against approaching tanks—has been made at the United States Army Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

About the size of a golf ball, and weighing only eight ounces, this new tube is the same type that enabled Allied radar to pinpoint enemy ships and planes through fog and darkness with greater accuracy in World War II.

The new tube is 50 times more powerful than the Klystron tube it is designed to replace, and uses far less filament battery power. It transmits on a frequency about 100 times higher than that used by FM broadcasting stations. It also is expected to be of military value in short-range field communications operations, as between advanced lines and rear echelons.

This extremely rugged tube physically resembles a standard-type receiving tube and operates from a plate supply of 450 to 500 volts and a heater supply of 6 volts.

Some commercial uses of the tube are deemed possible, such as in radar speed-control systems now used on superhighways and through some community thoroughfares.

The tiny magnetron tubes are made with watchmaking precision. Assembly of many parts, containing a dozen or more metals, requires highly skilled craftsmen. Microwave Associates, Inc., of Boston, Mass.,

under United States Signal Corps contract, is to produce the tubes from laboratory specifications.

The new tube was developed in the microtubes branch at Evans Signal Laboratory, a United States Signal Corps Engineering Laboratories component, under the direction of G. Ross Kilgore, director, Electron Devices Division.

Thin Translucent Acid-Proof Film Demonstrated

A thin, translucent barrier, a new type of film only four thousandths of an inch thick, is expected to protect delicate instruments from extremely corrosive atmospheric conditions. This new film made of Bakelite fluorothene resins has a tensile strength of about 25,000 pounds per square inch, equaling or bettering the strength of other fabricated films. W. S. Shamban & Co., Culver City, Calif., produces the chemically inert film for applications in chemical, electronics, packaging, and other industries which demand an unusual combination of physical, chemical, and electrical properties. Tough and flexible, this film withstands highly corrosive chemicals such as fuming nitric acid and hydrazine, both used as rocket fuels.

This chemical resistance is demonstrated with an ordinary pocket watch having parts sensitive to corrosion which remained unaffected when sealed in a film package and completely immersed in fuming nitric acid held at 230 F. A 10-penny nail dropped in at the same time completely dissolved in less than a minute. However, after five minutes in this highly corrosive bath the film-sealed watch was unaffected and continued to run. High dielectric strength of the film over a wide range of temperature and humidity conditions provides a positive and heat-resistant insulation for resistors, capacitors, transformers, and other electrical components. Resistance to moisture, fungus growth, and hydraulic shock makes this translucent film useful for packaging.

FLOUROTHENE FILM protects watch from corrosive nitric acid bath.

Dragline Moved 7 Miles Using Caterpillar Mobile Electric Set

Transferring a 560-ton Marion 7400 walking dragline 7 miles with mobile power has just been accomplished by Saxton Coal Corporation, Petersburg, Ind. It is believed to be the first time a dragline of such size has been moved as far with mobile power in a period of only 7 days.

A power source was needed to provide enough electricity for the dragline to walk and also to make some of its own cuts. Three methods for moving the unit were possible. Disassembly and reassembly, in three months was most expensive; erecting utility power lines, time and again would be less expensive but take 30 days. The least expensive, taking the shortest time, was to use the mobile power as was done.

Saxton executives attending a meeting of the Open Pit Mining Association in Hibbing, Minn., saw a Caterpillar Mobile Electric Set on display. Powered by a Caterpillar *D397* Electric Set, this unit is capable of delivering 315 kw. Inquiry showed that more than one set would be needed for the transfer.

After negotiations with Caterpillar Tractor Co., Peoria, Ill., a tentative moving date was arranged. The second unit, a *D397* was used to reduce complications. These two units made a total of 630 kw available.

Right-of-way easements across private property were negotiated. Crop damage, a separate item, was paid after the dragline crossed the property. Working permits were acquired for railroad and powerline crossings.

In all a total of seven roads, five power lines, and three railroads were crossed. No special charges were levied and only charges for time and labor were assessed by these concerns.

One-thousand feet of power cable was used to walk the dragline. This allowed the unit to travel 2,000 feet before the Caterpillar Mobile Electric Sets would have to unhook, move, and reset 1,000 feet beyond the dragline.

Whenever possible, the dragline traveled around the clock. However, when highways railroads, or power lines were reached, night travel ceased.

To facilitate this round-the-clock operation, a total of 18 men were needed. Each shift comprised six men, not including Caterpillar personnel, in charge of the electric sets, or supervisory personnel of Saxton.

The most difficult obstacles were the state highways, the bottom land, and the south fork of the Patoka River. There was always the danger in low terrain that the dragline would bury itself.

Several times the dragline's route passed over the little- and big-inch pipelines. It also passed over several waterlines. Before passing over these lines a protective cover of earth was laid. The amount of fill used varied according to the depth of the lines.

On one occasion a member of the Oakland City (Ind.) Water Department used a divining rod to locate a siphon pipe. This seemed ironic beside the expensive equipment used during this operation. Landowners along the route had their property fixed by a second Caterpillar *D7* Tractor with dozer and a Bucyrus Erie *15B* dragline.

The Marion *7400* averages approximately 400 feet an hour in good terrain. Each step covers about 6 feet, and during this 7-mile trip the 560-ton unit was lifted up and down approximately 7,400 times.

WALKING DRAGLINE of Saxton Coal Corporation being transferred 7 miles with two Caterpillar Mobile Electric Sets providing power. The move took 7 days.

The Caterpillar Mobile Electric Sets supplied adequate power for the dragline's operations. The peak load was 560 kw while walking, and 600 kw when digging in heavy material. More power was needed when the dragline traveled downhill than uphill because the unit had to be lifted against the grade. Voltage at the electric sets never dropped more than 5 per cent during peak loads; this did not include the line loss of 1,000 feet of power cable.

The new Saxton strip mine area will be located near the town of Oakland City, population 3,500, and is expected to produce slightly more coal per year than the old area which approximated 200,000 tons.

International Union of Crystallography to Hold Symposium

The International Union of Crystallography (I.U.Cr.) collaborating with Consejo Superior de Investigaciones Cient ficas will hold a symposium on "Structure on a scale between the atomic and microscopic dimensions" in Madrid, Spain, April 2–7, 1956. The results obtained by various well-known and new techniques including X-ray and electron diffraction and microscopy will be discussed. Those wishing to present papers should send the title and a 10-line abstract to the program chairman prior to January 1, 1956. Address them to: Prof. A. Guinier, Conservatoire National des Arts et Metiers, 292 Rue St. Martin, Paris (3e), France. Two I.U.Cr. Commissions (Crystallographic Apparatus and Crystallographic Teaching) will also hold meetings during this period. Further information may be obtained by writing to the secretary of the local committee Dr. M. Abbad, Serrano 118, Madrid, Spain.

The Fourth General Assembly and International Congress of I.U.Cr. will be held at

McGill University, Montreal, Que., Canada, July 10–17, 1957, and will be followed by two symposia July 18–19. Additional information will appear as notices in Acta Crystallographica.

Nuclear Demonstration Gives Town Atomic Power and Light

Electricity, produced from nuclear energy has been used to light and power Arco, Idaho, the first community in the United States to receive its entire supply of power from a nuclear source. On July 17, 1955, electricity, produced in an experimental nuclear power plant operated by Argonne National Laboratory at the United States Atomic Energy Commission's National Reactor Testing Station 20 miles away, was fed into transmission lines supplying the small town.

When reactor power was cut in, utility lines supplying conventional power to Arco from the Utah Power and Light Company were disconnected. The entire community of 1,200 inhabitants then depended solely on nuclear power for more than one hour.

Although the transmission of electricity from the nuclear power plant to Arco was by prior arrangement discontinued after the demonstration had been completed, the generation of electricity at the testing station site was continued.

A motion-picture record of the demonstration was presented to the United Nations for use at the International Conference on Peaceful Uses of Atomic Energy, at Geneva, Switzerland. The United States delegation plans to make the film available during the conference to representatives of 72 nations in attendance.

The experimental nuclear power plant, known as "Borax," short for "Boiling Reactor Experiment," was the subject of a major technical paper presented to the conference August 9 by Dr. Walter H. Zinn, director, Argonne National Laboratory. The plant, which generates more than 2,000 kilowatts of electricity, was designed and constructed by the laboratory. Harold V. Lichtenberger, who is a United States technical adviser at Geneva, is director of the laboratory's activities at the test station.

The reactor for the nuclear power plant has been under development by the laboratory since 1953. An experimental facility for conducting studies of a reactor of this type was constructed at the testing station site in the summer of 1953 and tests on safety and steady state operating characteristics were conducted. The tests were sufficiently encouraging so that additional studies were made in the summer of 1954.

Experience gained during the operation of this reactor warranted the addition of a turbogenerator so that the steam being produced could be converted into a more usable form of energy. This generation plant was placed in operation on June 28, 1955, and the production of electricity is continuing on a routine basis.

The reactor consists of a pressure vessel containing an assemblage of enriched uranium-bearing plates submerged in water, plus a number of neutron-absorbing rods. The water circulates through the reactor core by natural convection. Steam, produced by the heat created by the fissioning of uranium atoms, is conducted to the 3,500 kilowatt turbogenerator, located in a nearby building.

The simplicity of construction, ease of operation, low cost, and high degree of safety suggest the possibility that this type of small power plant may be suitable for use in remote areas or in conjunction with various types of mining or manufacturing operations.

Camera Control System Is Developed by ARCD

Development of an automatic, electronic remote-control system to operate aerial cameras in high-speed photo reconnaissance airplanes, recently was disclosed by the Air Research and Development Command, Headquarters, Baltimore, Md.

The equipment, known as the Universal Camera Control System (UCCS), automatically controls camera settings and operation in flight, constantly adjusting for light, altitude, and ground speed variations. The system can operate in flight without human attention. A single navigator-photographer, as in the RB-47E aircraft, for instance, can also monitor and manually adjust the system.

The equipment is flexible in that it can easily be adapted to control 1, or as many as 11 cameras, depending upon the photo coverage desired, and eliminates the need for many individual controls on each camera. UCCS thus substitutes electronic judgment for human judgment, and does a faster and more accurate job. The new camera control system is being used for both high-level and low-level photography missions by Air Force reconnaissance aircraft.

Personnel of the Aerial Reconnaissance Laboratory at Wright Air Development Center laid out the performance requirements and general electronic design. A number of electronic and photographic equipment manufacturers then developed and constructed the system. Included were the Bill Jack Scientific Instrument Company, which did much of the development work, A. B. DuMont, Chicago Aerial Industries, and Fairchild Camera and Instrument Corporation.

The heart of UCCS is a series of analogue

ELECTRICITY, produced from atomic energy by "Borax," an experimental boiling water nuclear power plant operated by Argonne National Laboratory (ANL) at the Atomic Energy Commission's National Reactor Testing Station, was used for more than one hour on July 17, 1955, to light and power the town of Arco, Idaho. Meyer Novick, ANL engineer (left), turns valve to release steam from Borax reactor into the turbine which drives 3,500 kw capacity generator, at right. Interior (right) of ANL's Borax reactor building. Reactor is in a pit under lower platform; reactor control rod mechanism is in the vertical housing. Arco was first community to be lighted exclusively by nuclear power on a city-wide basis.

computers. On a typical photographic reconnaissance mission, information regarding the focal length of each camera's lens and the cameras' angles in relation to the horizon are set into the system manually. Other information concerning film sensitivity, shutter speed, and focal length and type of lens is also manually set on the system.

When the airplane is in flight and the photo run is about to begin, the pilot or navigator-photographer manually feeds ground speed and/or altitude information to the UCCS. (If necessary, this information could be fed into the system before takeoff.) After that, all operation is automatic, and the system constantly determines and adjusts the cameras to accomodate any variations in lighting, ground speed, or altitude.

Both daylight and night photography can be controlled by UCCS. In a night photographic mission, UCCS records when each flash bomb or cartridge has been released, and calculates when each is to explode. Shortly before the explosion, UCCS opens the shutters of all cameras. When the bomb explodes, UCCS closes the shutters of each camera and is ready for the next bomb or cartridge already in the air. In the event a bomb or cartridge misfires, UCCS will close the shutters even though there has been no visible flash of light for activation.

The UCCS is constructed on a unit or "building block" plan so that its many electronic assemblies are interchangeable. Thus, if any portion of the equipment fails, it can be replaced quickly by a new "black box." Not only does this simplify maintenance and supply, but it also enables the operator to quickly locate faulty units by plugging the suspected unit into another circuit to check its operation.

Army Develops First Voice-Powered Telephone

The human voice has been tapped for power by the United States Army Signal Corps Engineering Laboratory, Fort Monmouth, N. J. to operate a new radio-telephone device. The development is considered to be a great boon both to military installations where electric power and wiring may be at a premium and to families where monoplizing of the phone is invariably cause for friction.

Completely independent of wires and batteries, the voice-operated equipment weighs only a pound and a half and continues to operate as long as the user keeps talking into it.

The technique employed puts the voice to work so that it both runs and operates a transistorized transmitter. After speech syllables strike the microphone, part of the power is filtered to operate the radio-telephone, while the rest puts "intelligence" into the signal it sends out. Thus, voice energy is substituted for electric energy in transmission.

At the present stage of testing, this new kind of energy does a competent job up to 600 feet. Further development plans call for a companion receiver weighing about three ounces, which could be powered by the same source. Voice energy would be built up and stored in the set when sending and used later for receiving.

The new voice-powered radio-phone was conceived and developed by George Bryan, an engineer in the Physical Sciences Division of the laboratories. He housed his experimental unit in the shell of an ordinary military telephone.

Military applications of the device are obvious: Transistorized transmission could eliminate batteries in both walkie-talkies and hand-held tactical radios, cutting weights in half and easing the soldier's burden.

As for civilian uses, engineers look forward to the day when small, self-contained radio-telephones will be used by businessmen to call the office while walking along the streets, by policemen operating in pairs, by hunting and fishing parties, newspaper reporters, firemen, and others who must be in constant communication with headquarters.

VOICE-POWERED RADIO TRANSMITTER experimental model built in a telephone instrument shows wavy lines on oscilloscope. The tiny transmitter uses the impact of sound waves from speaker's voice to power electronic signal.

United States Army Reveals 50-Language Writing Machine

An Army soldier soon will be able to write efficiently in over 50 different languages on one typewriter-like device although totally unacquainted with the language he is typing. This remarkable achievement was announced by the Department of the Army.

This durable, space- and weight-saving machine will be incorporated in mobile psychological warfare printing units.

Research on this multilanguage modified Vari-typer was undertaken to satisfy requirements of the United States for a means of communicating with populations in the major political and geographic areas of the world. Logistical and operational problems pointed to the need for eliminating bulky, movable type, typesetting, and reproduction equipment, and for reducing related operating difficulties in the field. The basic problem was to develop a composing machine simple enough to be operated by a nonlinguistic soldier. A single machine with interchangeable type fonts to permit writing the major alphabetical language was needed.

The Army Quartermaster Corps and the Office of the Chief of Psychological Warfare studied available equipment and recognized the Coxhead Vari-types and its mate, the Coxhead-Liner, as being most adaptable for this purpose.

Manufactured by the Ralph C. Coxhead Corporation, Newark, N. J., these machines have been sold for the composition of office forms, booklets, and reports to be reproduced by commonly used methods of Mimeograph and Offset printing.

Interchangeable type fonts simplified the Army's problem with languages in the Latin alphabet. The problem was different with Hebrew, Arabic, the Indo-Chinese languages using Sanskrit, or a language such as Burmese with over 700 characters, in comparison to 26 letters in the English alphabet.

After exhaustive research in languages and with hundreds of engineering changes, the Army now has a Coxhead Vari-typer which writes in over 50 languages, including a reverse carriage model which types from right to left, needed for writing Hebrew, Arabic, Persian, Urdu, Malayan, Jowi, and Pushtu; languages spoken by relatively small linguistic groups. The Coxhead-Liner does a similar job in large sized types for headlines.

This new "50-Language Vari-Typer" is simple to operate. The message is written by a linguist in the language desired then appropriate numbers are substituted for the characters, with diagonals, circles, and squares to indicate punctuation. With the proper font in the machine, the operator

strikes the keys according to numerical sequence of the message. Completed, the typing resembles commercial printing. This is photographed; an offset plate is made and printing begins.

Canadian Engineers Honor Colonel John By

A fountain which stood in London's Trafalgar Square (England) from 1845 until 1948 has been placed on the bank of the Rideau Canal in the Center of Ottawa, Ont., Canada.

To honor the founder of Bytown, and designer and constructor of the canal, The Engineering Institute of Canada arranged a luncheon at which Colonel By's association with Ottowa and contribution to the Rideau Canal were presented by Dr. R. E. Heartz, president of the organization.

Following the luncheon, guests proceeded to the fountain site beside the canal for the unveiling of the fountain and two plaques set in the cut-stone wall backing the fountain. An honor guard and a military band were in attendance provided by the Royal Canadian Engineers.

AT UNVEILING CEREMONY of Colonel John By Memorial are, left to right: Dr. R. E. Heartz, president of The Engineering Institute of Canada; the Honorable R. H. Winters, Minister of Public Works; Brigadier J. L. Melville, honorary colonel commandant of the Royal Canadian Engineers; and R. F. Legget, chairman of Ottawa branch, The Engineering Institute of Canada. All four are members of The Engineering Institute of Canada.

Customer Service Film Test Laboratory Opened

A new sales development and technical service laboratory, the most modern and complete of its kind, has been placed in operation by the Du Pont Company's Film Department at Chestnut Run, near Wilmington, Del.

The laboratory, built at a cost of approximately $1 million represents an expansion of Du Pont's program of service to customers in applications and use of cellophane, "Mylar" polyester film, acetate film, cellulose sponges and sponge yarns, and cellulose bands. Its work includes exploration of new markets for these products and also is concerned with improvement of quality, properties, and utility of these products in all manufacturing phases.

Operations range from physical testing of products to design and development of packages and packaging machinery, investigation of problems of printing and laminating, and exploration of electrical and industrial applications of films.

To help solve customers' problems, the laboratory is equipped to duplicate or approximate closely the conditions of film department products used in the customers' plants and serviceability of the item in the marketplace.

It has a set of six rooms in which extremes of weather may be reproduced on a controlled basis. Temperatures in these rooms range from 0 F to 100 F, and relative humidities from 20 per cent to 90 per cent. Observation of package performance in these rooms enables the laboratory to tell the manufacturer what type of packaging film he should use and how he should use it for best results under conditions he is likely to meet in his particular market, both for produce and for fresh and processed meats.

The laboratory has a versatile laminator,

DU PONT FILM DEPARTMENT'S sales development and technical service laboratory (above) is completely equipped for testing electrical properties of "Mylar" film and other insulating materials used in transformers, motors, and other electrical equipment. Operator checks polyester film (right) taken from a capacitor that has just been given a high-voltage test on the apparatus at left.

specially designed to permit reproduction of any laminating conditions a customer might encounter. It can be used to combine two flexible webs, such as cellophane and aluminum foil, for a special packaging application or it may be used to combine a flexible film, such as "Mylar" polyester film, with a rigid material, such as wood or steel, for an industrial use. It may be used with water-emulsion adhesives or solvent-solution adhesives, and the adhesives may be applied in a variety of methods actually used in the trade.

Although a major portion of the laboratory's effort is devoted to packaging all the way from original design to testing of the finished product, a substantial part of its work is directed toward industrial uses. The electrical laboratory has facilities for winding capacitors with "Mylar" insulation and for testing them under simulated conditions of use. It also has complete equipment for testing "Mylar" as a dielectric material in transformers, motors, and other electric equipment.

Cable Tension Measured for Installation Pull-Force Requirements

A newly developed electrical method provides a continuous record of forces required to pull electrical cables through underground conduits. The method is being used to study pulling techniques; the objectives being installation of longer lengths of cable and prevention of damage by excessive stresses.

Electrical measurement and recording of fluctuating cable tension are made practical by an *SR-4* load cell, supplied by Baldwin-Lima-Hamilton Corporation. The load cell does not deflect perceptibly under load because the load-sensitive element is a steel bar on which *SR-4* resistance wire strain gauges are bonded. Maxima of fluctuating load records can be read within plus or minus 150 pounds and mean loads, which are obscured by fluctuations, are estimated to be within 500 pounds.

The recorder was modified with a built-in electronic amplifier and bridge circuit for null balance in force measurement, and with a selsyn motor and 60-to-1 gear reduction unit to drive the round chart which shows feet of pull vs pulling tension. This motor is controlled by a selsyn transmitter connected to a foot-counter wheel so mounted that it is held in contact with the wire rope.

A maximum pulling force of about 20,000 pounds was observed for a maximum length of 3,300 feet of cable. Pulling speeds were normally between 20 and 35 feet per minute, as determined by timing recorded lengths being pulled. The charts obtained provide a graphic record of instantaneous loads, making possible a better evaluation of the factors contributing to pulling tensions.

Industrial Storage Batteries Use Polyethylene to Lengthen Life

A decision has been made by Exide Industrial Division of Electric Storage Battery Company to switch from rubber to polyethylene in the construction of industrial storage batteries. Tubing and tube sealers which encase the active material and grid spines of the positive plates of all Exide-Ironclad industrial batteries will be made exclusively of polyethylene. The manufacturer has found that use of this plastic with their slotted-tube plate design lengthens battery life and makes possible increased capacity.

Polyethylene construction benefits, which Exide has made available in electric industrial truck batteries since 1953 and in railway car lighting and air-conditioning batteries since 1954, now will be extended to all Exide-Ironclad users for diesel starting, mine locomotive power, marine, fire alarm, and police telegraph applications.

An increase of up to 20 per cent in battery working life is expected as a result of using polyethylene. Batteries tested in severe electric industrial truck use were found to have almost full-rated capacity after five or more years. In other rugged breakdown service life tests, polyethylene tube cells were able to deliver 80 to 82 per cent of capacity when rubber tube cells had only 37 to 42 per cent of capacity and competitive flat plate cells had only 3 to 12 per cent of capacity.

The big advantages of the finely slotted polyethylene tubes are that they withstand a wide range of working conditions within a battery, retaining their ideal original design dimensions, and elasticity. Polyethylene elasticity makes this plastic superior for slotted tube battery plates. Expanding and contracting freely while the battery is cycling, the tubes permit the pores of the active material to open and deliver full current. As the active material contracts the polyethylene holds it firmly in contact with the grid spine and prevents loss of active material.

Effectiveness of polyethylene battery parts has permitted an increase in size of plates without corresponding increase in size of case. This lengthens working life and increases battery developed capacity.

Quality can be controlled precisely, and polyethylene chemical properties and grades can be specified to assure conformity to highest standards. Through development and research, Exide assures users of a progressively better product. Use of translucent polyethylene permitted introduction of additional manufacturing control, visual inspection procedure to assure complete filling of every tube with active material.

Present suppliers of polyethylene for these batteries are Bakelite Company, a Division of Union Carbide and Carbon Corporation, and E. I. du Pont de Nemours and Company (Inc.).

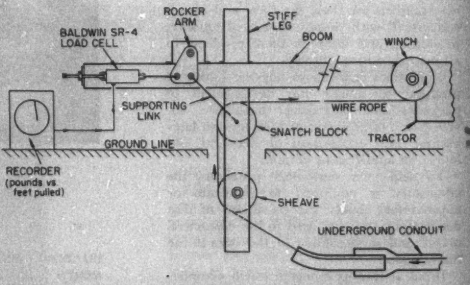

Fig. 1 (left). The forces necessary to pull cable through underground conduits are measured electrically by the Baldwin *SR-4* load cell, which has 50,000 pounds capacity, is 12 inches long, and 6½ inches in diameter, held in tension in the boom end, and are recorded by the instrument being observed in foreground. Wire rope is pulled by winch at far end of boom over a snatch block above the manhole. Radio communication is maintained with cable-feeding crew a half mile away. This system was developed by Philadelphia Electric Company. Fig. 2 (above). Schematic diagram of the cable-pulling tension measuring system used by Philadelphia Electric Company.

1956–57 Graduate Fellowships by National Science Foundation

Applications are now being received in connection with the National Science Foundation's Fifth Annual Graduate Fellowship Program. During the next few months, college seniors and graduate science students throughout the United States will compete for more than 750 fellowship awards for a year of graduate scientific study during academic year 1956–1957. Applications for the 1956–1957 National Science Foundation Fellowship Program may be obtained from the Fellowship Office, National Research Council, Washington 25, D. C. The closing dates for receipt of applications are December 19, 1955, for postdoctoral applicants; and January 3, 1956, for graduate students working toward advanced degrees in science. Selections will be announced on March 15, 1956.

National Science Foundation fellowships are awarded to American citizens who will begin or continue their studies at the graduate level in mathematical, physical, biological, medical, engineering, and other sciences during 1956–1957 semesters. For the first time this year, the Foundation will award fellowships in fields of convergence between the natural sciences and the social sciences. Approximately 20 fellowships will be awarded in such convergent fields as mathematical economics, demography, information and communication theory, and history and philosophy of science.

Selections will be made solely on the basis of ability. The majority of the fellowships will go to graduate students seeking master's or doctor's degrees in science. About 80 awards will be made to postdoctoral applicants. Graduating college seniors in the sciences desiring to enter graduate school are encouraged to apply for the awards.

The rating system for selection of predoctoral Fellows will be based on: (1) test scores of scientific aptitude and achievement, (2) academic records, and (3) written evaluations of each individual from his faculty advisors and other qualified observers. Postdoctoral applicants will not be required to take examinations. Applicants will be rated by special fellowship panels, established by the National Research Council. Final selection will be made by the National Science Foundation.

For additional pertinent information, inquiries should be addressed to the National Science Foundation fellowships award committee.

SHOWN INSPECTING A SCALE MODEL of the Army Package Power Reactor, first nuclear-power generating station to be erected in the Washington, D. C. area, left to right are: Kenneth Kasschau, ALCO manager of atomic engineering; Colonel James B. Lampert, chief of Army reactors branch; W. S. Morris, executive vice-president of ALCO; Admiral Lewis L. Strauss, chairman, United States Atomic Energy Commission (AEC); and Admiral W. D. Leggett, United States Navy (retired), ALCO vice-president of engineering. The unit was designed and is to be built by the company under AEC contract at Fort Belvoir, Va., during 1956 and will be in service by early 1957.

Revised Regulations for Electrical Equipment of Ships

The council of The Institution of Electrical Engineers have authorized the preparation of a fourth edition of the "Regulations for the Electrical Equipment of Ships," to supersede the existing Third Edition (1939) as amended by the 1947 Supplement.

Comments or suggestions from interested bodies or persons should be addressed to the Secretary of The Institution of Electrical Engineers, Savoy Place, London, W.C.2, England, and should be received by the committee on regulations on or before January 1, 1956.

NICB Held 4th Atomic Energy Conference

The 4th Annual Conference on Atomic Energy in Industry, sponsored by the National Industrial Conference Board, Inc., 460 Park Ave., New York, N. Y., was held October 26–28, 1955, at the Waldorf Astoria Hotel, New York, N. Y. Approximately 20 sessions were held covering a wide variety of pertinent topics, such as nuclear power costs, safety, and health; atomic power plant construction and operation; the outlook for nuclear transportation; reactor designs, research, and package; reactor uses; radioisotope uses; applications of gross fission products; and the investment outlook in atomic energy.

In a paper outlining the use of package power reactors, Rear Admiral W. D. Leggett, Jr., of ALCO Products, Inc., Schenectady, N. Y., explained that an atomic powered generating station now can be operated for as little as a third more than a conventional power plant. The fuel cost of such a station would be 7–8 mils per kilowatt-hour, as compared with 5–6 mils for chemically fueled plants operating on fuel costing 40 cents per million Btu.

In the opinion of John Davis of the Department of Trade and Commerce of Canada, nuclear power may be able to win its way against the other sources of energy on the North American continent sometime around the year 1965.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

An Arithmetical Curiosity

To the Editor:

The determination of integral values of X and Y to satisfy $X^3 = PY^3 + 4$, P being prime, has considerable interest. For any one value of P it is easy to write down innumerable fractional values, since a general solution is available; but the chance of hitting an integral one is generally remote and indirect methods must be sought.

The case of $P = 97$ is particularly interesting; a solution is given by $X = 125619266$, and $Y = 12754704$ which values are, I believe, the lowest for this prime, but result in 17 digits on each side of the equation. That such a number, and nothing less, can absorb or make use of the 4 is remarkable. Incidentally, other solutions are deducible from this one, the first of them requiring 17 digits for X. Perhaps a digital computer, in an idle spell, might seek the smallest solution for $P = 97$, and confirm or refute the claim that the figures quoted are the lowest.

ALLEN B. FIELD (AM '03, F '13, Member for Life)
1928 Lamme Medalist,
(Retired, Newbury, England)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MICROWAVE SPECTROSCOPY. By C. H. Townes and A. L. Schawlow. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 698 pages, 9¼ by 6¼ inches, bound. $12. The aim of this book is to give a systematic and complete account of the theory and techniques of microwave spectroscopy. The discussion is especially full for phases of the theory of molecular spectra not adequately tested by older methods, and some attention is paid to obtaining information on nuclear and molecular properties. Details of construction and operating characteristics of various types of microwave spectroscopes are also presented, and appendixes give data necessary for investigating and interpreting microwave spectra.

POWER PLANT MANAGEMENT. By Robert Henderson Emerick. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1955. 339 pages, 9¼ by 6 ¼ inches, bound. $6.50. A guide intended to aid all levels of management in making decisions regarding the design, administration, and operation of power plants. Such subjects as the most suitable method of power generation, storage of fuels, the outdoor power plant, specification writing, safety, training of personnel, smoke prevention, maintenance, etc., are treated from the standpoint of the executive who wants to produce dependable power at low cost. Detailed mathematical analysis has been voided in the discussion of engineering problems.

PRINCIPLES OF NUCLEAR REACTOR ENGINEERING. By Samuel Glasstone. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1955. 861 pages, 9¼ by 6¼ inches, bound. $7.95. This is a broad, over-all review of fundamental scientific principles, prepared for engineers who wish to know something of the impact of nuclear energy on their professional activities. It may also serve as a text for senior and graduate students. The separate chapters cover essentials of nuclear physics, reactor theory, instrumentation and control, fuels and materials, and various associated problems of reactor design. A number of existing reactors are briefly described in the last chapter.

PROCEEDINGS OF THE SYMPOSIUM ON PRINTED CIRCUITS. Sponsored by Engineering Department of Radio-Electronics-Television Manufacturers' Association. Engineering Publishers, G.P.O. Box 1151, New York 1, N. Y., 1955. 122 pages, 11 by 8½ inches, paper. $5. These proceedings contain the transcript of a panel discussion on techniques of producing printed wiring boards and 23 papers were delivered at sessions devoted to problems of design and production, reliability and service, management, components, and manufacturing. Subminiature circuits, silver migration, special clad materials, standardization, automation, quality control, and related topics are dealt with in the individual papers.

WERKSTOFFKUNDE DER ELEKTROTECHNISCHEN ISOLIERSTOFFE. By Hans Stäger. Gebrüder Borntraeger, Berlin, Germany, second edition, 1955. 470 pages, 9¼ by 7 inches, bound. DM 75. The first two sections of this treatise on electrical insulating materials cover gaseous and liquid types. The third, and largest, section is devoted to solid dielectrics. The book presents both theoretical considerations and an extensive compilation of practical data, much of it is presented in the form of useful graphs and tables. The thorough coverage includes chapter bibliographies and detailed indexes.

THE COMPUTER DIRECTORY 1955. (Computers and Automation, vol. 4, no. 6, June 1955) Published by Berkeley Enterprises, Inc., 36 West 11th Street, New York 11, N. Y. 162 pages, 10½ by 8½ inches, paper. $4. The first part of this directory is a list of about 7,500 persons in the field giving addresses and, when available, brief biographical information. Part two is a roster of organizations making computing machinery and supplying services of components. Part three is a classified directory of products and services for rent or for sale.

THE METALLURGY OF ZIRCONIUM. (National Nuclear Energy Series) Edited by Benjamin Lustman, Frank Kerze, Jr. First edition, 1955, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 776 pages, 9¼ by 6¾ inches, bound. $10. This volume is a critical review by more than 50 contributors of the many aspects of zirconium technology. Occurrence, reduction, refining, properties, and uses are covered in detail, and full chapters are devoted to melting and shaping, joining and finishing, and corrosion. Emphasis throughout is on proved techniques and practices.

THE PRINCIPLES OF ELECTROMAGNETISM. By E. B. Moullin. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., third edition, 1955. 438 pages, 9½ by 6¼ inches, bound. $7.20. The four major sections of this book cover the elements of magnetism, the second law of electrodynamics, iron in magnetic field, and two groups of special electromagnetic equations. In this edition, new material has been included on high-frequency resistance of rods and coils, and a set of 20 worked examples on cylinders and tubes in magnetic fields has been added.

REGELUNGSTECHNIK. Edited by "Fachausschuss für Regelungstechnik des Vereines Deutscher Ingenieure und des Verbandes Deutscher Elektrotechniker" 1954, Deutscher Ingenieur-Verlag, Düsseldorf, Germany. 282 pages, 9¼ by 6¼ inches, bound. DM 24. A compilation of 27 lectures on control engineering grouped under the following headings: fundamentals; technology of regulators; process-controlled systems and regulators; regulators for the process industries; regulation of drives; regulation of power plants and electrical networks; control of a d-c generator; and brief glossary of equivalent German, British, American, and French terms.

SCHALTUNGSTHEORIE UND MESSTECHNIK DES DEZIMETER- UND ZENTIMETER-WELLENGEBIETES. By Albert Weissfloch. 1954, Birkhäuser Verlag, Basel, Switzerland. 308 pages, 9¼ by 6¾ inches, bound. 33.50 fr. Circuit theory and measurement techniques in the decimeter and centimeter wavelengths. It covers general quadripole circle theory, circuits with homogeneous lines and their measurement, compound switching components and the variation with frequency of transformation properties, and tuning or matching procedures.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

NEMA Standards Publication for Molded-Case Circuit Breakers, AB 1-1955. This publication covers air circuit breakers, single-pole and multipole, assembled as an integral unit in a supporting and enclosing housing of insulating materials, for current ratings up to and including 600 amperes in frames not exceeding that rating, for voltages up to and including 600 volts alternating current, 250 volts direct current, and with interrupting capacities of more than 1,000 amperes. Information is given concerning the ratings, testing and manufacturing, and the terms used throughout the book are defined. $1.75. For copies send to National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

Writer's Fact Sheet on Home Fixture Lighting. A 10,000-word digest of technical and decorative information on home fixture lighting. Originally intended as a guide for writers and editors, the fact sheet is also being used for speakers' outlines, as a home economist teaching aid, and for sales training purposes by utilities, manufacturers, and others. 50¢ each. For quantities of more than 10, the price is reduced to 25¢ each. Copies can be obtained from the American Home Lighting Institute, 542 S. Dearborn Street, Chicago 5, Ill.

Organ Builders Manual. This publication describes all phases of electronic organ building, including console design, tone generators, manuals, pedals, amplification, and accessories. Also included is a parts-price catalog on the Artisan line for amateur organ builders. $1. Copies can be obtained from Electronic Organ Arts, 4878 Eagle Rock Boulevard, Los Angeles 41, Calif.

ARI Standard for Room Air Conditioners. The new Standard, which is designated as Air-Conditioning and Refrigeration Institute (ARI) Standard 110-55, was prepared by the Institute's Room Air-Conditioner Engineering Committee. The section on Rating Requirements, which ties in manufacturing tolerances with published capacity and other ratings, is the key provision in the 16-point program for advertising and selling room air conditioners developed recently by ARI and the National Better Business Bureau. Also included in the Standard for the first time are the minimum power factor values recommended by ARI and the electric utility industry. 35¢. Those desiring copies should write to ARI, 1346 Connecticut Avenue, N. W., Washington 6, D. C.

Automatic Record Changer Service. This sixth of the Changer Manual series covers 20 different basic changers and recorders. The Photofact technique is applied throughout the manual. From a laboratory examination of the equipment, complete data is presented on operation, adjustment, troubleshooting, and service for each unit. The exclusive "exploded-view" diagrams along with photographs, parts list, and complete write-ups make each service problem easy to diagnose and remedy. Wherever they apply, Photofact Standard Notation Schematics are also included. A cumulative index of this manual and the five preceding manuals in the series enables the technician to quickly locate the data on any specific unit. An additional feature is the list of receivers by the manufacturer's make and model showing which basic mechanism was used in a particular set. This cross-reference listing provides for the maximum use of the manuals in determining the particular unit used and in obtaining necessary replacement parts. 288 pages, $3. Available from Howard W. Sams and Company, Inc., 2201 East 46th Street, Indianapolis 5, Ind.

Atomic Energy Guidebook. A comprehensive and authoritative sourcebook covering every phase (civilian use) of the atomic energy field. It is a nontechnical reference source for those already in atomic energy, and contains a wealth of information for those who want to enter the field. It contains answers for those who want to explore the possibilities of atomic energy, or who want to find out how nuclear energy and devices can speed production, improve quality, cut costs, and increase profits. The book is in three sections, and runs the gamut of atomic energy from the mining of uranium to its end uses. The guidebook contains 30 separate articles and the directory—$7.50 per copy. Order from Callahan and Hollowell, 1420 New York Avenue, N. W., Washington 5, D. C.

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• A screwdriver and five seconds are all you need to remove this new **PLUG-IN** relay for normal inspection, maintenance or replacement! That's big news in these days of "pushbutton" operations when even a few minutes of down-time can mean thousands of production dollars down the drain.

Square D Field Engineers have sensed this ever-increasing problem in their contacts with machine tool builders and industrial plants throughout the country. Square D design engineers have followed through with this, the first **plug-in** relay built specifically for machine tool use. Another example of design leadership!

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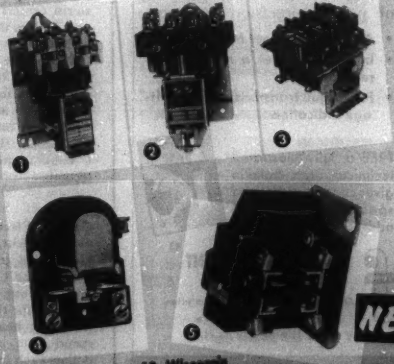

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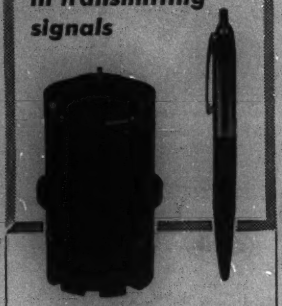

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Ford Instrument's standard components

INDUSTRIAL NOTES ...

AGE Generating Unit. American Gas and Electric (AGE) Company is planning construction of another 225,000-kw steam-electric generating unit at their Muskingum River Plant in Beverly, Ohio. The project will cost an estimated $28 million and will be completed about June 1957. The new unit, capable of supplying electric service to 650,000 average homes, will make the Muskingum River station one of the two largest power plants in Ohio, second only to the Kyger Creek Plant of Ohio Valley Electric Corporation.

Westinghouse Awarded Generator Contract. Westinghouse Electric Corporation has been awarded a $2 million contract for a 113,000-kw turbine generator for Pennsylvania Power Company. The delivery date for the generating unit has been scheduled for August 1957 and will be installed as unit Number *4* in Pennsylvania Power Company's New Castle power plant. The planned increase in generating capacity is necessary because of the growing demand for electric energy in Pennsylvania Power Company's service area.

Weather Detection System to Be Installed. Installation of weather detection radar equipment developed by the Radio Corporation of America (RCA) will be made on the new *DC-7C's* of the British Overseas Airways Corporation (BOAC). The weather detection radar system provides pilots with early warning of approaching storm centers as far distant as 150 miles, and enables them to detect and follow non-turbulent air paths through or around the storms. The equipment purchased by BOAC is to be installed aboard 10 *DC-7C* aircraft during 1956. Several American commercial airlines have installed similar equipment on transcontinental and overseas fleets. The RCA system operates at *C* band frequency—5,400 megacycles per second.

General Electric News. General Electric vice-president, Dr. W. R. G. Baker, predicted that, despite automation, employment in the United States will continue to grow by one and a quarter million jobs annually for the next 15 years. Dr. Baker said that nearly a thousand plants will spend from a quarter to a half million dollars each in 1955 on facilities of a super-mechanical nature, controlled by electronic processes. The General Electric official noted that automation's stimulation has come from the military services. However, results obtained in automatic production for the military have created an eager market for commercially applicable equipment.

A $500,000 expansion of the testing facilities of the company's Switchgear and Control Division's laboratories has been completed. The new testing facilities are expected to produce short-circuit currents as high as 100,000 amperes at 700 volts, and 40,000 amperes at 1,400 volts.

A 2,500 kw geared-turbine-generator to be used in the prototype of the United States Army's first "packaged" atomic reactor being built by Alco Products, Inc. will be supplied by the General Electric Company. The "packaged" atomic power plant will be capable of producing enough power to supply the average requirements of a city of 5,000 people. The geared-turbine generator, weighing approximately 20 tons, will be built at the company's small turbine and supercharger department. The atomic reactor will be built by Alco at its plant in Schenectady, N. Y. When completed in 1957, the "packaged" atomic power plant will be located at the United States Army Engineers Research and Development Laboratories at Fort Belvoir, Va., and will be used to train personnel. The power generated will be consumed in normal post operations.

A General Electric Company plant costing over $5 million will be built at Lynchburg, Va., as the new home for the company's rectifier department, now located at Lynn, Mass., and at Limerick, Maine. The plant will eventually employ about 800 persons, more than 600 of whom will be hired from the local area.

Columbia University Acquistion. The School of Engineering, Columbia University, New York, N. Y., acquired the huge steel radio tower on the west bank of the Hudson, 14 miles from New York City at Alpine, N. J., it was announced The familiar landmark opposite Yonkers, N. Y., together with its permanent brick laboratory building, was acquired from the estate of the late Major Edwin H. Armstrong, inventor of fm radio and long a professor of electrical engineering at Columbia University. To be known as the Edwin H. Armstrong Field Laboratory, the facilities will be used by the department of Electrical Engineering for research in radiation and propagation of various types of radio waves, particularly with respect to their behavior in the atmosphere, ionosphere and upper atmosphere. In addition to the Alpine site, Columbia University also has acquired from the Armstrong estate 57 acres of land in the towns of Catskill and Hunter, New York. This area includes one of the taller peaks of the Catskill Mountains. These two new sites plus Columbia's engineering camp near Litchfield, Conn., will form a triangular range for extensive field studies in radar and radio.

Reactor Facility. Nuclear Development Corporation of America, (NDA) White Plains, N. Y., will build a reactor "critical" facility at its Nuclear Experimental Station in Dutchess County, N. Y. The facility is

intended for use in the reactor engineering program carried out for governmental and industrial clients by NDA. The corporation is applying to the Atomic Energy Commission (AEC) for a license to carry out nuclear experiments at the facility. It is also maintaining close liaison with the Reactor Safeguard Committee of the AEC in developing plans for the facility.

Ebasco Forms Atomic Energy Division. Ebasco Services Incorporated plans the addition of a Nuclear Engineering Division to its engineering department. The company will render services on atomic energy applications to utility companies, industrial concerns, business enterprises, and finanical institutions. Leonard F. C. Reichle, who has transferred to Ebasco from the post of assistant director of the Reactor Development Division of the United States Atomic Energy Commission, has been appointed nuclear engineering director. Walter F. Friend who has been engaged in the nuclear activites of the company, will continue as nuclear engineer. Within the Ebasco organization, atomic energy will be in the consulting engineering department along with the Electrical, Mechanical, Civil, Gas, and General Divisions under Howard L. Melvin, chief consulting engineer.

Bogue Supplies Static Rectifier at Paducah. Bogue Electric Manufacturing Company, has announced that two giant 480-kw static rectifier supplies have been built by Bogue for Union Carbide Nuclear Corporation, Division of Union Carbide and Carbon Corporation for use at the Atomic Energy Commission installation at Paducah, Ky. Used to supply controlled direct-current power, the new static rectifier supplies are providing the necessary energy for depolarizing large electrolytic cells employed in the production of fluorine.

Synthetic Mica Plant Opens. A new plant designed solely for the production of synthetic mica has been opened. The company, known as the Synthetic Mica Corporation, is a wholly owned subsidiary of the Mycalex Corporation of America, Clifton, N. J., manufacturers of glass-bonded mica and ceramoplastic products. This strategic material, under the tradename Synthamica, has been under production for several months.

Presque Isle Station Goes Into Service. The new $4 million Presque Isle Station which has been placed in operation for the Upper Peninsula Generating Company, a nonprofit operating company formed by two concerns in need of power and now able to obtain it on a less costly basis by combining their generating efforts, will produce 22,000 kw for the expanding industrial needs of Michigan's upper peninsula. Stone and Webster Engineering Corporation was retained separately in 1952, by Upper Peninsula Power Company, an independent utility, and The Cliffs Power and Light Company, a subsidiary of The Cleveland-Cliffs Iron Company. Both company's initiated construction programs to be undertaken by Stone and Webster and realized the advantages of interconnecting their systems and jointly constructing a larger, single power plant which would be less costly to build and operate.

New Teletypewriter Relay System Completed. A new semiautomatic Teletypewriter relay system has been placed in service for Consolidated Freightways by the Bell Telephone System. Heart of the system, which stretches through 12 states, is a relay center located in Portland, Ore. The Portland center serves as an electronic brain which controls the sending and receiving of Teletypewriter messages from 65 locations of the motor transport carrier. The new system was developed by the long lines department of American Telephone and Telegraph Company and by Pacific Telephone and Telegraph Company to expedite messages dealing with dispatch of Consolidated's vehicles. Consolidated moved 2,168,364 individual shipments, weighing 1,005,364 tons, over a total of 59,969,850 intercity miles last year. To facilitate movement of such tonnage, the firm has located message and dispatch centers in 12 states.

Marquardt Power Unit Installed. The Chance Vought *XF8U-1* Day Fighter, a new Navy jet fighter aircraft, is equipped with a Marquardt ram-air emergency power package designed to bring the airplane home if all other power supplies should fail. The emergency power unit was developed and produced by Marquardt Aircraft Company, in close co-operation with Chance Vought. It supplies both electric and hydraulic power, sufficient to maintain flight control and communication through all speeds from supersonic down to safelanding. This power package was developed to operate as a "drop-out" type in which a trigger pushes the machine out into the air stream, and the air turbine starts rotating immediately to drive the hydraulic pump and electric generator.

Dalic Appoints Marlane as Distributor. Dalic Metachemical Ltd. of Toronto, Ont., Canada, has appointed the Marlane Development Company of 153 East 26th Street, New York, N. Y., as a distributor for The Dalic Process of selective localized electroplating. Marlane, a consulting firm specializing in the development of modern processes for plating and engineering industries, will be responsible for all inquires and technical servicing of The Dalic Process.

Manufacturing Technique Enables Minimized Background Noise. A new process for commercial production of records has been announced by Custom Records, Inc., 41 East 42d Street, New York, N. Y. This process enables the mass production on a commercial scale of records with playback quality that closely resembles the hi-fi performance of the original master record.

School of Nuclear Science and Engineering Graduation. The first session of the School of Nuclear Science and Engineering at Argonne National Laboratory has ended and the 39 scientists and engineers have been graduated. The school which was

(*Continued on page 18A*)

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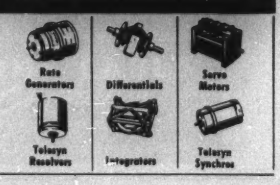
Ford Instrument's standard components



How Rome Synthinol® Control Cables serve Philadelphia Electric at its New Cromby Station

Philadelphia Electric Company, privately owned and an important producer of electrical power, has recently completed its eighth large generating station—Cromby.

The Cromby Station will increase the capacity of Philadelphia Electric's system by 17% to keep pace with booming industrial and residential development of the Delaware Valley.

Cromby is a two-unit station. Already in operation is a 150 megawatt steam generator and an additional 200 megawatt unit will be operating by mid-1956.

Over 1,500,000 conductor feet of Rome Synthinol Control Cables were used at Cromby. There are two major applications . . . remote control of high-voltage yard circuits and regulation of the soot blowers. Underground cables for yard control are insulated with Rome Synthinol, rated at 60°C.

You, too, can specify Rome Synthinol Control Cables with confidence.

The Cromby story is continued in the picture captions . . .

The development of cables, having multiple conductors under a common nonmetallic sheath, in which Rome has played an important role, has been of inestimable value in station control planning. Not only do they save installation time and costs but provide good mechanical protection, as well.

The fundamental application of Rome's product is in control of the 33,000, 66,000 and 132,000 volt yards. There the Rome Synthinol (polyvinyl chloride) insulated and sheathed cable is buried directly in earth.

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Every factor was weighed carefully before specifying polyvinyl chloride for underground work. Its qualifications fitted two very important requirements at Cromby . . . high resistance to moisture and good dielectric strength.

The Rome underground cable at Cromby is expected to last a good many years. Its superior resistance to soil conditions assures long, trouble-free service life.

Installation experience under a wide variety of service conditions has proved polyvinyl chloride insulation and sheath to be extremely dependable—more economical than some other constructions.

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ANOTHER EXAMPLE OF *Waterman* PIONEERING...

The S-12-B RAKSCOPE is a rack mounted, JANized (Gov't Model No. OS-11) version of the famous WATERMAN S-11-A POCKETSCOPE, with the addition of a triggered sweep and a special calibrating circuit for rapid frequency comparisons. The entire oscilloscope is built to occupy but seven inches when mounted in a standard relay rack. The vertical and horizontal amplifiers are identical, having sensitivities of 0.05 Volt rms/inch and frequency responses which are flat within —2 db from DC to 200 KC. These features permit observation of low frequency phenomena without undesirable trace bounce. The sweep rate is continuously variable from 5 cycles to 50 KC in either the triggered or repetitive mode with synchronization polarity optional. The return trace is blanked. Because provisions are made for applying input signals from the rear, as well as the front, the S-12-B is the ideal combination, systems monitor and trouble-shooting oscilloscope. Investigate the multiple applications of this instrument as an integral part of your "rack mounted" projects.

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S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes
and Other Associated Equipment

Industrial Notes

(*Continued from page 15A*)

started in March 1955 is one of the major projects undertaken by the United States Atomic Energy Commission in co-operation with the State Department and the International Co-operation Agency in support of President Eisenhower's Atoms-for-Peace program. In the first session, which began on March 14 there were 30 scientists and engineers from 19 nations representing a cross section of applicants from Europe, Central and South America, and the Near, Middle, and Far East. The seven-month session included unclassified courses in design, construction, and operation of reactors for nuclear research; principles of design of nuclear power reactors; chemistry and metallurgy of reactor materials; handling of irradiated materials; and other related peacetime applications of nuclear energy. Enrollment for the second session of the school, to begin on November 7, is expected to reach 65.

Film Offered. Why do ships still have collisions? The answer to this question holds wide implications for mariners and others concerned with safety at sea. Marine insurance records continue to show occasional mishaps between vessels despite one or both being equipped with modern radar systems. Detailed information has been collected and presented by Raytheon Manufacturing Company, Waltham, Mass. producer of marine radar equipment, in a 20-minute motion picture film called, "Safe Passage." This movie is an important graphic supplement to the education and experience of mariners. It should contribute to the general understanding of radar by all ship and yacht owners and operators. Prints of the film for free showings to interested groups will be distributed by Raytheon's public relations department as a public service.

NEW PRODUCTS . . .

High Output Solar Cell. National Fabricated Products, Inc., Chicago, Ill., is now producing a silicon solar battery with design based on research and development by Bell Telephone Laboratories. Incorporating a hermetically sealed, large area, silicon p-n junction, the solar cell converts light to electrical energy. A single *S-1* cell under direct noon sunlight will develop 0.25 volts across a 10-ohm load and will produce electrical power at a rate up to 10 milliwatts. Maximum power output is flat at wavelengths from 7,000 to 8,500 angstroms; at wavelengths between 5,500 and 9,500 angstroms output is within 50 per cent of maximum. In addition to its high output the unit features compact size—only $1^3/_4$ inch diameter by $^3/_{16}$ inch thick.

New Current-Limiting Reactors. A line of stronger, lighter, and more durable current-limiting reactors is available from

(*Continued on page 22A*)

look beneath the braid

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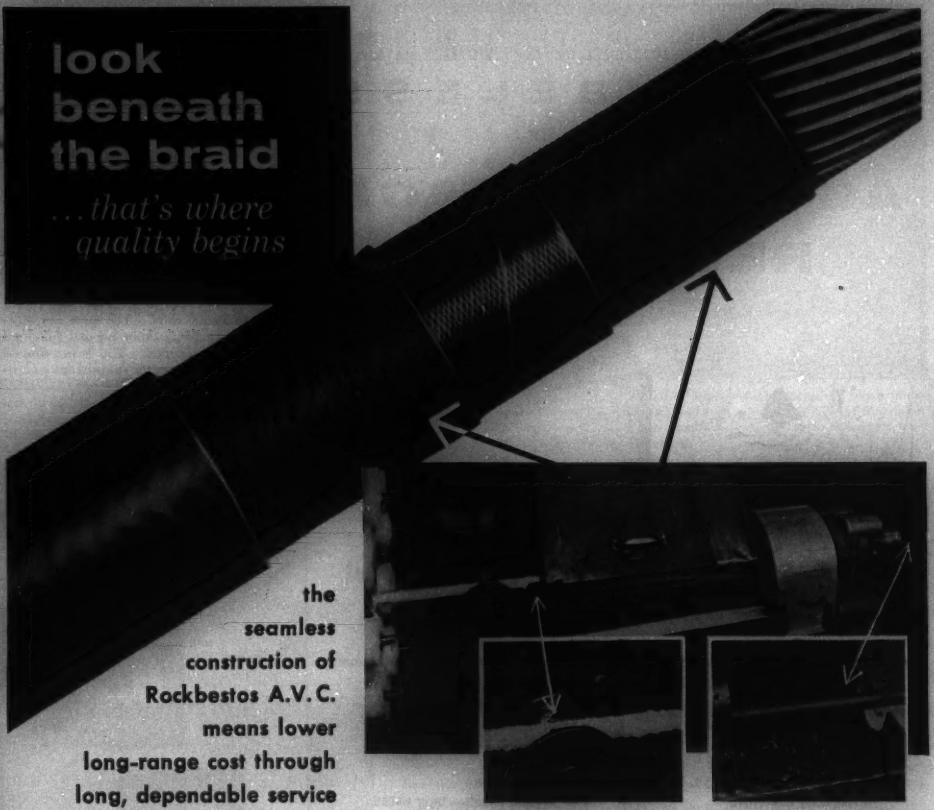

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Heavy, felted asbestos walls are applied over and under the varnished cambric tapes . . . then thoroughly impregnated . . . then the impregnated asbestos is compressed to a dense, homogeneous wall that ensures long cable life.

N.E.C. Type AVA wires or cables may look alike on the surface. But the proof of their quality is *under* the braid. Look for the dense, uniformly-impregnated, seamless walls of *Rockbestos A.V.C.* Type AVA.

The dense, felted, thoroughly-impregnated asbestos walls of *Rockbestos A.V.C.* seal the varnished cambric tapes away from air or moisture. This seamless construction gives *Rockbestos A.V.C.* added strength against damage from flexing. Heat dissipation is uniform. Dielectric strength *stays* high under conditions of high ambient temperature or moisture.

Complete construction and test specifications of *Rockbestos A.V.C.* Type AVA are in the new booklet: "Specifications RSS-88". Write for your copy.

STOCKED COAST TO COAST
Standard Rockbestos A.V.C. construction (N.E.C. types AVA, AVB, etc.) are available for immediate shipment. Call or write nearest branch office.

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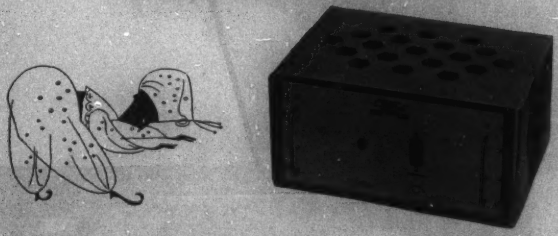
NEW TUBELESS

magnetic amplifier

AC LINE VOLTAGE REGULATOR



STABLVOLT® 3 KVA

MODEL MX 3000

- No tubes—no filaments
- Magnetic amplifier regulated
- Maintenance-free
- Adjustable output voltage
- Output held within ±0.25% RMS
- Frequency insensitive
- Excellent wave form
- Fast response
- No dangerous overvoltages
- Quiet operation
- Wide input range
- No jumbled toroids — layer wound

PERFORMANCE SPECIFICATIONS

Input Voltage:	100-130V RMS*, 55-66 cps, single phase
Output Voltage:	110-120V RMS, continuously adjustable
Output Current:	3KVA; 34 Amperes at 110 Volts 31.5 Amperes at 120 Volts
Output Voltage Regulation:	Within a band of ±0.25V RMS for line voltage variations from 100 to 130 V*; Line frequency variations from 55-66 cps, and load variations from 0.3 to 3KVA
Load Power Factor Range:	0.6 to unity
Response Time:	Less than 0.5 seconds
Harmonic Distortion:	5% RMS maximum
Overload Protection:	Automatic magnetic switch in AC line
Size:	19" x 10½" x 13⅜" deep
Weight:	Approximately 130 pounds

** At 3KVA load. Wider input range at lower loads.*

Also available: Model MX 1000 1KVA

For complete technical data request Engineering Bulletin EB-205.

MAGNETIC RESEARCH CORP.

2001 CENTER STREET • EL SEGUNDO, CALIFORNIA

Phone ORegon 8-9321

MRC

Manufacturers of Magnetic Amplifiers and Components Exclusively

Magnetic Logic Elements

New Products

(Continued from page 18A)

Westinghouse Electric Corporation. These reactors are used to limit short-circuit current to safe values, and to reduce effect of resulting voltage disturbance. The new reactor has cable-support columns built of polyester-glass-resin cleats and epoxy-resin tie rods to provide the high compressive and tensile strength required to withstand the thermal and mechanical forces imposed during short circuits. The reactors are designed for indoor or outdoor service in single or 3-phase ratings from 5 to 6,000 kva; 300 to 6,000 amperes; and 1,201 to 34,500 volts. The units can withstand up to 33⅓ times normal full load current for 5 seconds. The wedge-shaped cleat used in the reactor column has a high-dielectric value, and its resiliency to thermal and mechanical shock practically eliminates the aging and maintenance problems. For further information, write Westinghouse Electric Corporation, Post Office Box 2099, Pittsburgh, Pa.

Panel Instruments. DeJur-Amsco Corporation has announced two new self-contained 1⅓ inch precision panel instruments for audio system monitoring, and radar equipment. These meters, *VU*, and

DB, are available in square or round housings. They are designed to meet the size and weight requirements in aircraft and electronic equipment, which are subject to shock vibration or temperature extremes. Watertight sealing is accomplished by an internal locknut between the meter mounting flange and case barrel. Terminal studs are sealed in a similar manner. Various ranges, front or rear panel mounting, internal or external zero adjuster, and rear illumination are available in this series. For further information write to Electronic Sales Division, DeJur-Amsco Corporation, 4501 Northern Boulevard, Long Island City, N. Y., requesting technical data sheet *VU133*.

Askania Valve Actuator. The Askania Regulator Company has developed a new self-contained electrohydraulic valve actuator, which controls the complex equipment. With electronic control systems,

(Continued on page 26A)

DOWN a humid 180 feet below water level at Downsville Dam

Some 3600 feet of 2" Everdur Conduit (E.M.T.) protect electric lines in a service shaft plunging down to the release water chamber 180 feet below water level at Downsville Dam of the New York Metropolitan Water Supply System. Electric lines operate vital valves, indicating and communication equipment.

UP in the corrosive air at a water cooling tower

During the War, General Petroleum Corp. saw galvanized conduit fail within a year at one of its plants—replaced it with Everdur Conduit. At its new Ferndale Mobilgas Refinery in Washington, some 12,000 pounds of Everdur Conduit in various sizes guard electric power lines for motors and lighting in this water cooling tower.

EVERDUR Conduit will guard the electric power lines—for years

Everdur* Never Rusts. It offers high resistance to other types of corrosion. That's why Everdur Conduit—made from one of Anaconda's exclusive copper-silicon alloys—is specified for dependable year-after-year protection of electric power lines in industry, on bridges, at power and water supply projects—wherever water and corrosive atmospheres are a problem—or where conduit must be buried or embedded in concrete.

Everdur is Tough. In addition to corrosion resistance, Everdur has high physical strength, resists wear and abrasion. It stands up under movement and vibration, as on a bridge, in a subway, in a factory.

Everdur is Nonmagnetic. Everdur Conduit creates no magnetic field to produce temperature rise in electric power cables.

Everdur Electrical Conduit is available in two wall thicknesses —R.C. in nominal sizes from ¼" to 4", inclusive, and E.M.T. in nominal sizes ⅜" to 2", inclusive. For more detailed information write: The American Brass Company, Buffalo Division, Buffalo 5, N. Y. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

55120

*Reg. U. S. Pat. Off.

EVERDUR ELECTRICAL CONDUIT

ANACONDA®

COPPER SILICON ALLOYS

CORROSION RESISTANT • STRONG • NONMAGNETIC • WORKABLE • WELDABLE

VHF
VERY HIGH FREQUENCIES
radio interference and field intensity*
MEASURING EQUIPMENT

Stoddart Ri-Fi® meters cover the frequency range 14kc to 1000 mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-68. Very low frequencies.

HF
NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A. C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.

UHF
NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17 Frequency range includes Citizen's band and UHF color TV band.

PRINTED CIRCUITRY . . . Modern printed circuits offer many advantages over conventional wiring—lighter weight, more compact units and freedom from many of the troubles normally encountered in conventional electronic equipment. Vibration becomes even less of a problem with printed circuits, adding to the many portable features already available with Stoddart equipment.

ADVANCED DESIGN . . . Specialized engineering and modern production techniques have produced one of the most advanced instruments for the accurate measurement, analysis and interpretation of radiated and conducted radio-frequency signals and interference ever manufactured. Designed to laboratory standards, rugged, and with matchless performance, the versatile NM-20A is an outstanding example of modern instrumentation. Its frequency range includes FM and TV bands.

SMALLER SIZE . . . A wider frequency range and higher standard of performance is incorporated into an equipment whose size is one-third that of any similar equipment ever manufactured.

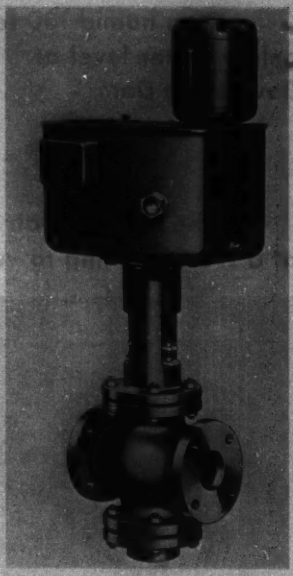
SENSITIVITY . . . Sensitivity ranges from one to ten microvolts per-meter, depending upon frequency and antenna in use.

APPLICATIONS . . . Field intensity surveys, antenna radiation pattern studies, interference localizer and measurement for checking radiation from virtually any mechanical or electrical device capable of generating or radiating radio-frequency signals or interference.

STODDART aircraft radio co., inc.
6644-B SANTA MONICA BLVD. HOLLYWOOD 38, CALIFORNIA HOllywood 4-9205

New Products

(*Continued from page 22A*)



measurements are converted to electric signals and fed into electronic amplifiers with proportional band, reset, and rate actions. The electric output signal of the electronic controller is then converted to a controlled air pressure which in turn operates a diaphragm-actuated control valve. Conversion to air for the operation of a final control element necessitates electropneumatic relays, compressors, dehumidifiers, and the like. This new valve actuator applies the electric output directly to the final control element. The signal current is applied to a high resistance coil, 3,000 ohms or more, which moves in a magnetic field. Linked to the coil is Askania's jet pipe which converts electric signals, less than 50 milliwatts, into the powerful stroke of a control valve. The valve moves at a speed of more than 1 inch per second. Thrusts of 600 pounds and more can be handled, with presently available strokes up to 2 inches.

Power Supply Units. Municipal fire alarm systems use the selenium bridge rectifier, shown in the illustration, as a continuous source of d-c power for fire alarm boxes throughout a community. Durable components, good voltage regulation during overloads, and protection against short-circuit damage are incorporated in the power supply. The unit has low internal impedance, choke-condenser hum filtering, and needs no warm-up. Power sources up to 500 volts d-c or 500 milliamperes for all types of

(*Continued on page 28A*)

BEST BRUSH... **BEST BRUSH LINE...**

NATIONAL BRUSHES
TRADE-MARK

Your best bet, *from individual application to your entire mine or mill requirement,* is "National" brushes...best because they give you maximum machine efficiency at minimum brush cost.

Here's why:

PROVED GRADES

Grades to suit every operating condition... widest selection in the industry.

RESEARCH AND DEVELOPMENT PROGRAM

Active, sustained program assures new brushes for new-design machines; continually improved brushes for existing machines.

TECHNICAL SERVICE

Helps you get best electrical performance and reduce maintenance costs...streamlines brush-buying practice.

Start saving brush dollars now in operation, ordering and handling...Specify "National" brushes and be confident of top performance throughout your mine or mill.

The term "National", the Three Pyramids Device and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

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A Division of Union Carbide and Carbon Corporation
30 East 42nd St., New York 17, New York

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco
IN CANADA: Union Carbide Canada Limited, Toronto

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SATURABLE REACTOR

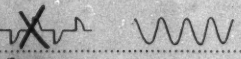
you should know about!

It is called the

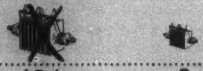
SELIN REACTOR

—and has these advantages:

LOAD CURRENT WITH MINIMUM HARMONIC DISTORTION .....



LOW DC POWER REQUIREMENT .....



FAST RESPONSE .....

DO you have an application where a sinusoidal load current is desired?

DO you need to reduce control power requirements?

WOULD it help if you could speed up response time?

The Hevi Duty-Selin Reactor may be the answer to your Saturable Reactor problem.

Write to the "Regulator Division" for further information about this important development. *(Pat. applied for)*

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

New Products

(Continued from page 26A)

signal or control systems are built in various mechanical arrangements to fit original equipment manufacturers' requirements. Also applicable to the excitation of magnetic chucks, small motors, alternators, dynamometers. For further information write to Slaughter Company, 1700 Nicklin Avenue, Piqua, Ohio.

Rib-Wound Power Wire-Wound Resistors. Spot-welded terminals and windings are among the features found in the new rib-wound power wire-wound resistors manufactured by Reon Resistor Corporation, New York, N. Y. The treatment of the terminals and windings adds durability and life to the component. A larger proportional increase in cooling area in comparison to tubular resistors of equal size is achieved by the corrugated edgewise wound ribbon wire. High thermal conducting Reon vitreous enamels permit operation at higher temperature rise without deterioration or damage. Standard

units are available in ratings up to 2,000 watts and up to 200 ohms resistance, and are designed for high-power circuits requiring units of high current and wattage ratings at low resistance values. These are adaptable to starter duty as well as continuous applications.

Fixed-Tuned Oscillator Triode. The Radio Corporation of America (RCA) tube *6562* is a fixed-tuned, ultrahigh-frequency oscillator triode having pencil-type construction for transmitting service in radiosonde applications. The design of the RCA *6562* incorporates two integral

(Continued on page 32A)

Locke's Insulator Catalog and Engineering Handbook

Designed to become your favorite source for complete, authoritative purchasing and engineering information on insulators and insulator hardware.

Included in its 233 pages of easy-to-use, alphabetically and numerically indexed material, you'll find these important features:

1. A completely new insulator product section, thumb indexed, makes it easy for you to quickly locate any one of over 800 insulators or insulator hardware items.
2. Complete description of physical characteristics of porcelain.
3. Six pages of clamp recommendations for various conductors.
4. Large section on lightning performance of transmission lines.
5. An expanded section on apparatus bushings with application and maintenance information.
6. Complete listing of all EEI-NEMA Standards, including proposed standards for apparatus insulators. (TDJ-58, 59)
7. The complete American Standards for apparatus bushings and test code.
8. A large general data section including standard insulator tests, cable specifications and many valuable tables for general calculations.

Your copy of this lightweight, spiral bound Insulator Catalog will be supplied by your local Locke Representative.

LOCKE

Announcing a BIG IMPROVEMENT

IN SMALL MOTOR BRUSHES

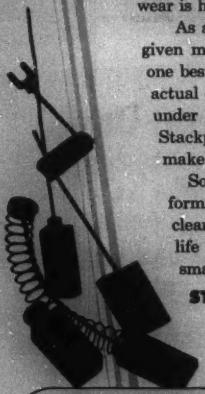
Exhaustive tests indicate that Stackpole Grade 373 fractional horsepower motor brushes represent a major development in their field.

On vacuum cleaners, food mixers, sewing machines, calculators, and similar equipment, these new brushes have shown *materially* longer life, usually with better performance than any previous grades. Commutator wear is held to a minimum.

As always in applying brushes to any given motorized equipment, however, the one best way is to test them fully on that actual equipment and as close to possible under its typical operating conditions. Stackpole welcomes the opportunity to make or to facilitate such a test for you.

Solely on this basis of positive performance proof, it now becomes pretty clear that Grade 373 brushes will set new life and performance standards for small motors in a wide diversity of uses.

STACKPOLE CARBON COMPANY,
St. Mary's, Pa.

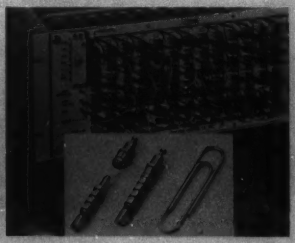


STACKPOLE
Grade 373
FAR LONGER BRUSH LIFE - *Plus*
EQUAL (OR BETTER) PERFORMANCE THAN PREVIOUS GRADES

(*Continued from page 28A*)

resonators of the cavity type. One of the resonators is fixed tuned and is connected between grid and cathode. The other, which is connected between grid and plate, is tunable over a narrow range centering at 1,680 mc and is loop-coupled to an r-f coaxial output terminal. Features contributing to the usefulness of the RCA *6562* in radiosonde service include high efficiency, small frequency drift, low battery drain, and small size. In addition, the RCA *6562* has its cathode externally connected to one of the heater leads to simplify circuit connections. The flexible heater leads can be soldered or welded into the associated circuit.

Quick Connectors. Illustrated is a *3C* building block component for a digital computer and control system by Computer Control Company, Inc., Wellesley, Mass., which employs new terminals by Cambridge Thermionic Corporation (CTC). The CTC jack, designated *X2200*, comes



in shank lengths for panels varying from $^{1}/_{32}$ to $^{5}/_{16}$ inch. It is 0.210 inch high when mounted; the diameter is $^{5}/_{32}$ inch. The plug, designated *X2201*, has a pin length of $^{5}/_{16}$ inch, and a body length of $^{5}/_{8}$ inch. It will accept up to number *20* size wire which can be soldered and then crimped through the insulation to prevent fraying. The unusual jack design assures electric connection. Through the use of a specially designed compression spring, the gripping power of the jack is maintained.

(*Continued on page 36A*)

AIEE SPECIAL PUBLICATIONS

To meet a specialized need, or where it has become advantageous to collate a number of papers on a subject in one pamphlet, a series of special publications has been established. Prices quoted are (M) for AIEE members, and (N) for nonmembers.

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DC POWER SUPPLY

Now...for Your Laboratory... the most versatile TUBELESS, Regulated and Filtered Power Supply

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Specifications . . . .

REGULATION: 5-32V Range: ± ½% for combined line changes of 105-125VAC and load changes of 0-15A. DC.

2-5V Range: ± 2% for combined line changes of 105-125VAC and load changes of 0-15A. DC.

32-36V Range: ± 2% for combined line changes of 110-125VAC and load changes of 0-15 A. DC.

RIPPLE: 1% rms max. @ 36 volts and full load. Increases to 2% @ 2 volts and full load.

AC INPUT: 105 to 125 volts, 1 phase, 60 cps. (8 amps. input)

RESPONSE TIME: 0.1 to 0.2 seconds maximum.

DIMENSIONS: 19½" wide x 15½" deep x 13¼" high with cabinet. (19" wide x 14¾" x 12¼" high rack panel construction)

FINISH: Gray Hammertone **WEIGHT:** Approx. 135 lbs.

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PERKIN ENGINEERING CORP.

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New Products

(*Continued from page 32A*)

A New Formica Laminate. A new cold punching laminate, *XXXP-36*, that brings translucency, greater accuracy, and super-insulation to printed circuitry has been announced by The Formica Company. Translucency of the new paper-base phenolic-impregnated sheets allows a visual

check on the accuracy of printed-circuit register, as shown in the illustration. It provides 1 million megohms insulation resistance. Since the laminate punches cold in thicknesses up to an including 1/16 inch, no heat cycle is required. Thus, the base laminate is not subject to dimensional change. Formica *XXXP-36* offers other useful properties which include high-dielectric strength, greater heat resistance, and superior bonding strength. It may be used for many applications other than printed circuitry. For a free printed-circuit sample write to The Formica Company, Cincinnati, Ohio.

Operational Amplifier. A new operational amplifier, Model *K2-X*, has been added to the Philbrick line of electronic analogue components, manufactured by George A. Philbrick Researches, Inc., Boston, Mass. Using a plug-in type high-gain amplifier as a base subassembly, feedback computing devices of all speeds may be assembled with simple wiring. Featured in this unit are balanced differential inputs for minimum drift and maximum utility, high performance, and economy of operation. Feedback operations include: addition, subtraction, integration, differentiation, proportioning, inversion, impedance conversion, and injection of current. The Model *K2-X* is a more powerful version of the Philbrick Model *K2-W*, offering higher performance with comparable stability. The two models are physically interchangeable and may coexist in instrument assemblies. For specifications write for Bulletin *K2-X*. Address inquiries to George A. Philbrick Researches, Inc., 230 Congress Street, Boston, Mass.

Wire Connection without Soldering. Quick connection of wiring without soldering is offered in the new *2,700* series of

(*Continued on page 40A*)

Saturation-Free Linear-Coupler System . . .

Air-Core Transformer Improves Bus Protection

System expansion, plus interconnection of systems, makes it imperative that reliable, high-speed bus fault protection be provided against lightning, interference and breakdown of insulation. For this purpose, a Westinghouse linear-coupler system offers two big advantages.

Simplicity

There is no saturation because there is no iron. The air-core transformer does not saturate, gives consistently true internal fault indication, assures dependable operation of relay and tripping of circuit breaker.

Linear couplers may be open circuited with complete safety without endangering personnel. Operating voltage of coupler is well within insulation limits of connected apparatus. Result: The most reliable scheme for protecting vital bus systems—using simple, compact, low-cost equipment.

Flexibility

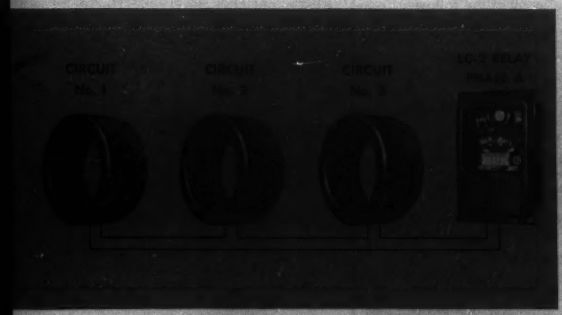
Design flexibility permits couplers to be applied in circuit-breaker bushing pockets, in metal-clad switchgear or on existing outdoor bus work.

Maximum flexibility for system expansion is also assured. As a system grows and more bus sections are added, additional linear couplers require only a change in relay setting achieved simply by changing the impedance tap. Coupler designs for switchgear of 15 kv through 230 kv are available.

Be sure to investigate linear-coupler systems for your operation. Call your Westinghouse sales engineer or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40488

YOU CAN BE SURE...IF IT'S

Westinghouse



System Simplified—Only one relay per phase is needed with this series connection. Expansion of system requiring additional couplers involves easy calculation for relay setting. Sum of voltages on coupler secondaries indicates relay setting.

Adjusts To System Growth—As system grows, additional linear couplers are installed without extensive recalibration or complicated resetting of relay—simple adjustment is made by changing impedance tap selector screw (arrow).

for $950

NON-LINEAR SYSTEMS new digital voltmeter--Model 450.

Designed especially for analog computers.

Uses oil-immersed stepping switches,

life-tested for 20,000,000 readings.

Measures from ±00.01 to ±99.99 volts d-c.

Presents in-line, luminous display.

write for bulletin 240

NON-LINEAR SYSTEMS, INC.
Del Mar Airport
Del Mar, California

MOBILE COMMUNICATION CENTERS

Radio Engineering Products has been continually in production of mobile communication centers for various NATO headquarters and for the U.S. Signal Corps Engineering Laboratories, over a period of several years. The centers produced have included type AN/MSC-1, type AN/MSC-5, and type AN/MSC-12, which have been or are being manufactured in full accordance with U.S. Signal Corps specifications. There have also been produced systems engineered by us to the specific requirements of a headquarters.

These systems have employed in some instances trailers and tractors of modified commercial types supplied by us, in some instances standard military-type vehicles supplied by us, and in some instances the using agency has supplied standard military-type tractors, trailers and trucks.

These centers have provided in mobile form, some or all of the following functions, in some cases in very complex and extensive form:

- Operations rooms for signal officers and commanders.
- Teletype conference viewer facilities.
- Teletype switchboards up to 120 lines.
- Telephone switchboards up to 600 lines.
- Testing of military and civil wire facilities.
- V-H-F and U-H-F broadband radio-relay terminals and repeaters.
- Multi-channel carrier-telephone and carrier-telegraph systems for superposing on wire and radio facilities.
- H-F frequency-shift radio transmitting facilities, and matching dual-diversity receiving positions.
- Teletype message-center, tape-relay, and cryptographic facilities.
- Mobile diesel power plants.

Radio Engineering Products has a broad and extensive knowledge of this subject, unparalleled plant facilities, and a team of engineers, production executives, and craftsmen which place us in a unique position in this field. We will gladly supply estimates on mobile comcenters to specific requirements on request.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY STREET, MONTREAL 3, CANADA
Telephone: UNiversity 6-6887 Cable Address: Radenpro, Montreal
MANUFACTURERS OF CARRIER TELEGRAPH, CARRIER TELEPHONE AND BROAD-BAND RADIO SYSTEMS

New Products

(*Continued from page 36A*)

tapered terminal and receptacle lugs, by United States Engineering Company, Inc. 521 Commercial Street, Glendale, Calif. These lugs come in six standard sizes which range from 0.328 above board with a 0.113 diameter, to 0.421 above board with a 0.118 diameter. Single-end or double end terminals, and feed-through types are available. They fit standard terminal board thicknesses from $^{1}/_{32}$ inch through $^{5}/_{16}$ inch. Designed for use in conjunction with Amphenol or similar pins, the tapered lugs are made of half-hard brass; either nonplated or silver plated.

Power Supplies. NJE Corporation, 345 Carnegie Avenue, Kenilworth, N. J., has announced the availability of its ELG line of semiregulated power supplies. These units employ germanium power rectifiers in conjunction with automatic line-regulating transformers and extremely "stiff" transformers and filters. Although no vacuum tubes, magnetic amplifiers, or saturable reactors are used, regulation comparable to such circuits is often obtainable. No electron tubes are used and minimum maintenance is required. In most models, efficiency is about 94 per cent. Average temperature rise is 5 C. No component is rated at less than 30,000 hours of continuous duty. A typical unit delivers 100 volts at 2 amperes, against line and load changes regulated to within 1 per cent, and has less than 0.1 per cent rms ripple. Most units can be economically designed for zero-lag transient response, so as to exhibit no transient deviation outside the regulated zone.

Pin-Type Weatherproof Socket. Rodale Manufacturing Company, Inc., Emmaus, Pa., has redesigned its medium base pin-type sockets. Incorporated in the new design is a built-in wing-type finger wrench on the cap section of the socket to provide faster, tighter connections. Pressure applied to the wrench forces the interior contact pins to puncture the insulating wire and make a positive contact. In addition to this improvement, the cap has a threaded brass bushing to receive the screw from the body of the socket. This feature results in a sturdier piece and provides longer service

(*Continued on page 42A*)

Simplex Cables power and control longest, single-span vertical-lift bridge in the world!

Cape side of canal with bridge span down. Seven of nine cables visible are Simplex-ANHYDREX. Light-colored square beneath catwalk is 1100-ton concrete counterweight that rides inside the framework of each tower.

U. S. Army's 544-foot railroad span over Cape Cod Canal raised 130 feet with ANHYDREX

The 2200-ton span, located near Buzzards Bay in Massachusetts, carries the only railroad track between Cape Cod and the mainland.

Army and Air Force installations on the Cape depend upon this track for supplies. Therefore, both normal and emergency electrical circuits on the bridge must be as near perfect as possible.

The railroad company that maintains the bridge specified Anhydrex-insulated cables with neoprene jackets. Army engineers, who own and operate the bridge, approved this choice.

ANHYDREX Cables withstand effects of moisture, corrosion from salt air, sunlight and swaying in high winds.

Want the same service from power and control cables as the Army engineers? Ask your nearest Simplex representative about ANHYDREX Cables, or write to the address below.

Closeup of ANHYDREX Cables. Mainland on left. Span is raised and lowered by two 150-horsepower electric motors that turn 16-foot sheave wheels atop the bridge's two towers.

Simplex-ANHYDREX

SIMPLEX WIRE & CABLE CO., 79 Sidney St., Cambridge 39, Massachusetts

I'm DALOHM... miniature but mighty!

You can depend on

TYPE RH MINIATURE POWER RESISTORS

For all applications where the equipment must survive the most severe environmental, shock, vibration, humidity and temperature conditions.

Completely welded from terminal to terminal. Silicone sealed in a die-cast black radiator finned housing and mounts on sub-panel for maximum heat dissipation. Impervious to moisture, salt ions, vapor and gases.

Three wattage ranges: RH-25, 25 watts; RH-50, 50 watts; RH-250, 250 watts.

- Temperature coefficient 0.00002/Deg. C
- Ranges from 0.1 ohm to 55,000 ohms depending on type
- Tolerances 0.05%, 0.1%, 0.25%, 0.5%, 1%, 3%, 5%

Conform to Applicable JAN and MIL Specifications

WRITE FOR BULLETIN No. R-21

DALE PRODUCTS, Inc.
1312 28th AVE., PHONE 2139
Columbus, Nebraska, U.S.A.

Export Dept.: Pan-Mar Corp., 1270 Broadway, New York 1, N.Y.

ILSCO CONNECTORS

MAKE YOUR PRODUCT PERFORM BETTER

All these . . . and more . . . for YOUR BEST CONNECTIONS

U/L AND CSA TESTED	HI-RUGGED STRENGTH
PURE COPPER	RE-USABLE
100% CONDUCTIVITY	ALL WIRE SIZES
COOLER OPERATION	ECONOMICAL

WRITE FOR 80-PAGE CATALOG

ILSCO CORPORATION
5743 Mariemont Ave.
CINCINNATI 27, OHIO

(Continued from page 40A)

life. Listed as catalogue number *233*, the socket has a medium base and takes either *12* or *14* gauge standard wire. The rating is 660 watts, 250 volts.

New Level Controller. A level controller that combines the advantages of electronic and air-pressure control instruments has been developed by Fielden Instrument Division, Robertshaw-Fulton Controls Company. The new device, called Pneutronic level control, utilizes the accuracy of electronic capacitance-sensing elements to detect minute changes in levels; electronic signals are then converted by the control into proportional pneumatic output. This modulating air output is sufficiently powerful to operate control valves and other pneumatic control equipment. Eliminated are servo motors and other rebalance mechanisms. Because of the modulating control action of the new device, much of the wear caused by "on-off" systems is avoided. Further information about the Pneutronic level control is available upon request from Fielden Instrument Division, Robertshaw-Fulton Controls Company, 2920 North Fourth Street, Philadelphia, Pa.

Dual-Purpose Wire. A dual-purpose wire which can be used as a building wire, and a machine tool or appliance wire has been announced by Anaconda Wire and Cable Company, New York, N. Y. Called Densheath *900*, the wire consists of a bare copper conductor insulated with an oil- and moisture-resistant Densheath (polyvinyl chloride) 90-C compound, and slipper compound over-all to insure ease of pulling in conduits. The wire is rated at 600 volts. Although the wire is dual-

(Continued on page 44A)

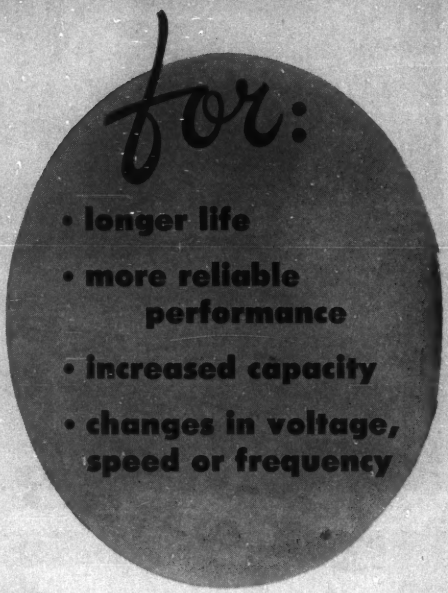
Let National Redesign Your Motors and Generators

Old fashioned motors and generators which can't keep up with modern demands. Electrical machines whose performance characteristics don't match changed operating conditions. Don't discard them until you check with National. Often such equipment can be redesigned and rewound to meet your new requirements for a fraction of the replacement cost.

Outmoded equipment can be rejuvenated by the introduction of modern winding techniques. Minor changes in design and materials often make a world of difference in length of life and reliability of service.

Need increased capacity from a generator? Need a motor converted to operate at a higher or lower speed? The table below shows a few of hundreds of instances in which National redesign of old equipment has saved a National customer the cost of a new motor or generator.

Write today for details, or get in touch with your nearby National field engineer.



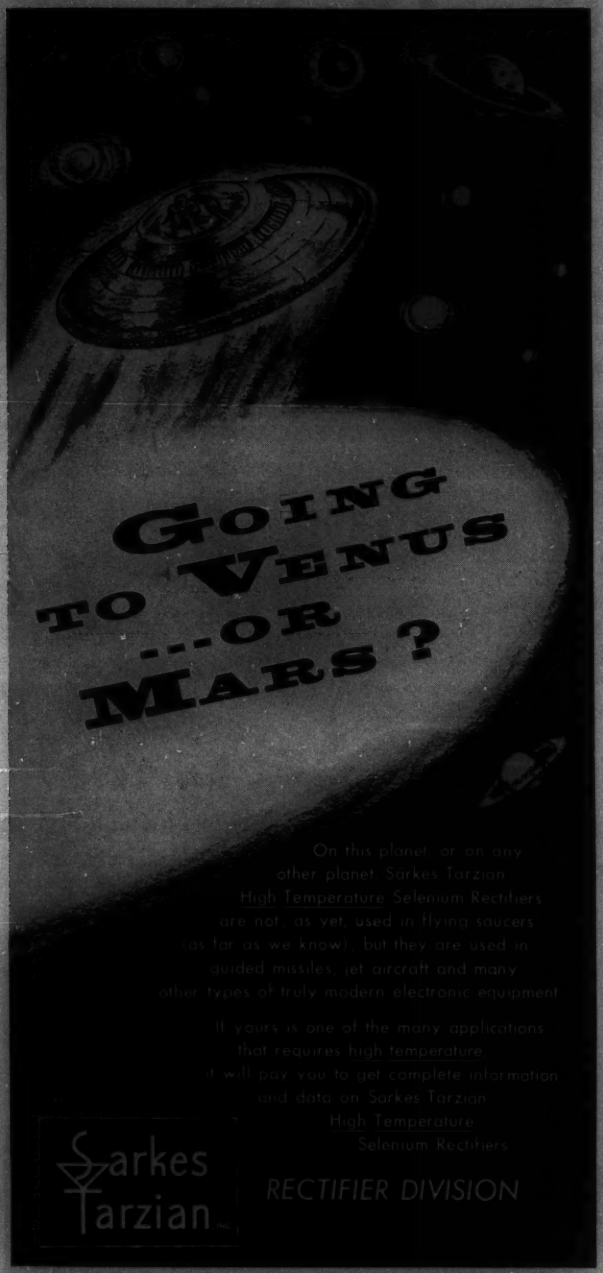
Typical National Conversions To Produce New Operating Characteristics

Type of Equipment	Rating before Redesign	New Rating
Steel Mill Motor	1875 HP, 900 RPM, 2200 volts, 3 phase, 60 cycles	1565 HP, 750 RPM, 4160 volts, 3 phase, 50 cycles
Waterwheel Generator	22,223 KVA, 171.4 RPM, 11,000 volts, 3 phase, 60 cycles	27,000 KVA, 171.4 RPM, 11,000 volts, 3 phase, 60 cycles
Motor	125 HP, 600 RPM, 4100 volts, 3 phase, 60 cycles	150 HP, 720 RPM, 2300 volts, 3 phase, 60 cycles
Turbo-generator	1563 KVA, 3600 RPM, 2300 volts, 3 phase, 60 cycles	1563 KVA, 3600 RPM, 480 volts, 3 phase, 60 cycles
Induction Motor	75 HP, 3560 RPM, 220/440 volts, 2 phase, 60 cycles	75 HP, 3560 RPM, 220/440 volts, 3 phase, 60 cycles

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES


GOING TO VENUS ...OR MARS ?
On this planet, or on any other planet, Sarkes Tarzian High Temperature Selenium Rectifiers are not, as yet, used in flying saucers (as far as we know), but they are used in guided missiles, jet aircraft and many other types of truly modern electronic equipment.
If yours is one of the many applications that requires high temperature it will pay you to get complete information and data on Sarkes Tarzian High Temperature Selenium Rectifiers.
Sarkes Tarzian
RECTIFIER DIVISION

DEPT. E-6, 415 N. COLLEGE AVE., BLOOMINGTON, INDIANA

In Canada: 700 Weston Rd., Toronto 9, Tel. Murray 7535 • Export: Ad Auriema, Inc., New York City

New Products

(Continued from page 42A)

rated, current ratings should be based on a maximum of 60 C when it is used as a TW wire in National Electrical Code applications. In locations outside the jurisdiction of the code, however, the wire can be used to a maximum of 90 C. When used as a machine tool or appliance wire, it carries Underwriters' approval as a 90-C wire.

New Kitchen Appliance Saves Space. An advanced step in the direction of home automation comes with the introduction NuTone, Inc., Cincinnati, Ohio, of a combination electric mixer, food blender, and knife sharpener. With one motor doing the work of three, the appliance takes

up less than half the space needed to store three separate appliances.

Every feature of the NuTone Electric is to save labor and speed chores. Its 300-watt motor, capable of heavy duty provides 6 speeds for mixing and blending jobs, and is twice as powerful as any other food-mixer motor.

Underfloor Wiring System. A two-level steel underfloor wiring system designed for commercial, industrial, and institutional buildings has been announced by General Electric Company's conduit products department, Bridgeport, Conn. The system consists of two levels of steel ducts with necessary fittings, and is designed to feed and distribute power, telephone, signal, and auxiliary systems. The lower level of duct is used to feed conductors from panel boxes to the upper level which in turn distributes conductors to the surface outlets. This steel underfloor system provides complete separation of high- and low-tension services. Separation is made possible because only single-duct junction boxes are used throughout. The box has duct entrances on two levels, which permits unobstructed runs without the necessity for special crossunders or crossovers.

Plug-In Tubular Capacitors. New "one-ended" case, solid dielectric paper tubular capacitors designed for special requirements of printed wiring board assemblies

(Continued on page 46A)

◀ **Coil being driven into slots.** Tight fit shows importance of accurate tolerances and dimensional stability.

▲ **Quinterra Type 5—2 ply** is here being applied to the flat section of armature coil to form basic cell insulation. For abrasion resistance, a wrapping of untreated glass tape is applied over the Quinterra before final varnish dip and hot press cure.

Why West Virginia Armature Co. switched to J-M QUINTERRA® for armature coil insulation

West Virginia Armature Co., Bluefield, W. Va., is a leading manufacturer of motor armature coils, used by the coal mining industry—a severe and difficult field. It was only after 4 years of field testing that they decided to change to Johns-Manville Quinterra Type 5—2 ply for their traditional built-up insulation materials. They made this change because they discovered that:

1. Quinterra retains higher inherent dielectric strength under prolonged high temperature operating conditions.
2. Quinterra, manufactured to closer thickness tolerances, permits more accurately dimensioned coils, assuring easy and proper fit.
3. Quinterra is pliable, conforms readily to shape of coil and remains dimensionally stable in storage or in use.
4. Quinterra is smooth, does not crack or flake, is easy and pleasant to handle, does not harm or irritate operators' hands.
5. Quinterra is flexible, eliminates dielectric failures due to flaking or splitting.

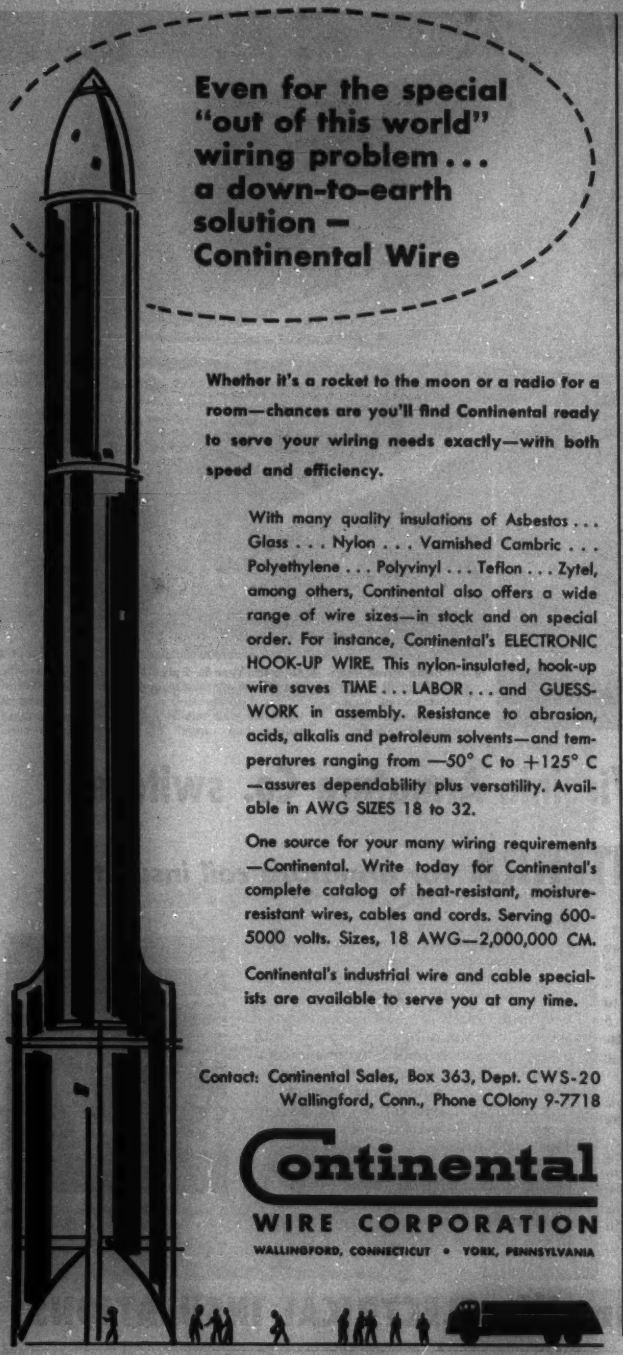
Quinterra Type 5—2 ply is made from two sheets of highly purified asbestos treated with a polyvinyl acetate resin saturant and combined under controlled temperature and pressure. It has ample mechanical strength for easy handling. Its inherent dielectric strength exceeds 280 VPM even at temperatures over 130 C.

Find out how you can obtain the same benefits from Quinterra. Write for free 32 page illustrated brochure, EL-40A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit (Toronto), Ontario.

Dimensional accuracy is imperative. Here, finished coils are being tested in Go-or-No-Go gauge.

JM PRODUCT

Johns-Manville ELECTRICAL INSULATIONS



Even for the special "out of this world" wiring problem . . . a down-to-earth solution — Continental Wire

Whether it's a rocket to the moon or a radio for a room—chances are you'll find Continental ready to serve your wiring needs exactly—with both speed and efficiency.

With many quality insulations of Asbestos . . . Glass . . . Nylon . . . Varnished Cambric . . . Polyethylene . . . Polyvinyl . . . Teflon . . . Zytel, among others, Continental also offers a wide range of wire sizes—in stock and on special order. For instance, Continental's ELECTRONIC HOOK-UP WIRE. This nylon-insulated, hook-up wire saves TIME . . . LABOR . . . and GUESS-WORK in assembly. Resistance to abrasion, acids, alkalis and petroleum solvents—and temperatures ranging from —50° C to +125° C —assures dependability plus versatility. Available in AWG SIZES 18 to 32.

One source for your many wiring requirements —Continental. Write today for Continental's complete catalog of heat-resistant, moisture-resistant wires, cables and cords. Serving 600-5000 volts. Sizes, 18 AWG—2,000,000 CM.

Continental's industrial wire and cable specialists are available to serve you at any time.

Contact: Continental Sales, Box 363, Dept. CWS-20
Wallingford, Conn., Phone COlony 9-7718

Continental
WIRE CORPORATION
WALLINGFORD, CONNECTICUT • YORK, PENNSYLVANIA

New Products

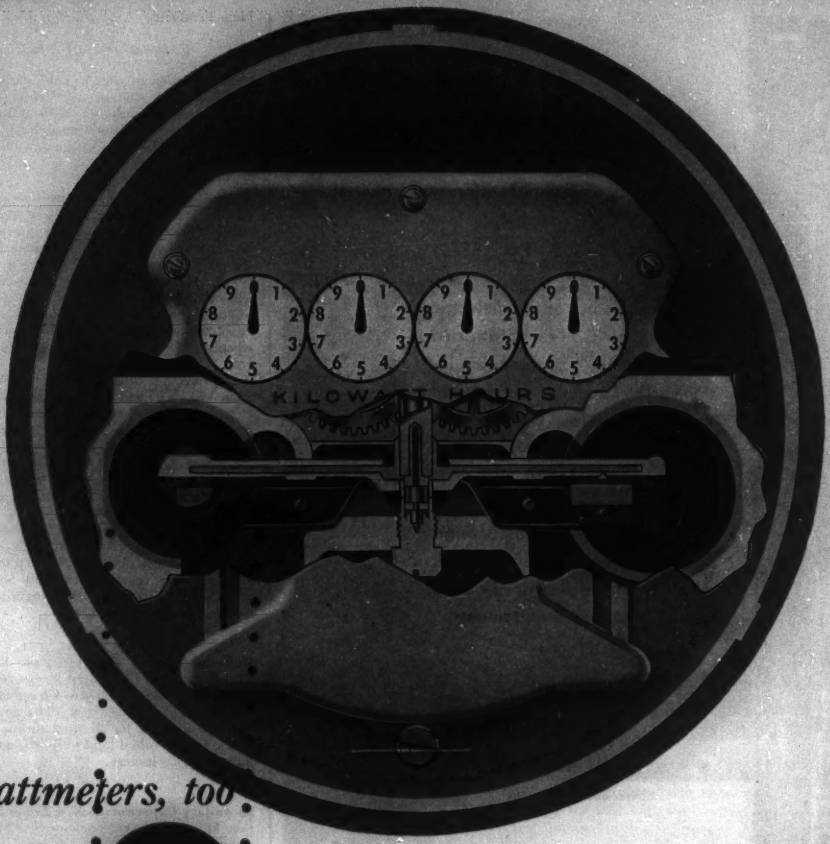
(*Continued from page 44A*)

has been announced by the Sprague Electric Company, 321 Marshall Street, North Adams, Mass. The Autocon capacitors are enclosed in a premolded cylindrical shell of nonflammable thermosetting plastic with the capacitor section sealed against the entrance of moisture by a plastic resin endseal bonded to the phenolic housing. The two short, straight leads which issue from the endseal are held at a closely controlled distance from each other. An index key molded in the phenolic housing adjacent to the outside foil lead facilitates identification of the lead for automatic insertion by machinery or hand operators. In addition, three stand-off feet raise the endseal and shell proper above the printed wiring board, avoiding moisture and dust trap formed by capacitors with a flat circumference on the housing. Complete performance data, ratings, and sizes of the new capacitors are in Engineering Bulletin *222*, available on letterhead request to the Technical Literature Section of the Sprague Electric Company.

Light Switches. The Arrow-Hart and Hegeman Electric Company, Hartford, Conn., has announced an addition to its line of Quiette light switches, the new interchangeable Quiette lock switch. Designed with lock-type handle, the new switch is turned on and off only with the key provided. This will prevent tampering with the light switch—especially in public buildings, institutions, or wherever the possibility of having lights turned on and left on unnecessarily exists. The interchangeable lock switch is available in 15 ampere 120–277 volt a-c only, single pole, double pole, 3- or 4-way, with either screw or screwless wire-lock terminals and certain types with line shunts; or 20 ampere 120–277 a-c only with binding screw terminals.

Frequency-Diversity Microwave. Microwave equipment which provides maximum circuit continuity has been developed by Motorola Communications and Electronics, Inc. Two simultaneous beams at different frequencies are transmitted to a distant station. The same information is impressed on both beams, and the receiver automatically selects the better received signal. The equipment was developed for special applications, requiring maximum possible reliability, such as transmission of automatic long-distance dialing signals in a commercial telephone system. Equipment is available for locally controlled indoor or remotely controlled outdoor installation. Microwave transmitter and receiver units are packaged in plug-in boxes for fast, efficient maintenance. A single antenna system transmits both beams. FM subcarrier or telephone-type (single side-band suppressed carrier) multiplex equipment can be used. Both types of multiplex equipment accommodate all standard telephone functions, enabling the microwave equipment to be integrated into an existing telephone system as a supplement

(*Continued on page 48A*)



wattmeters, too

USE CRUCIBLE PERMANENT MAGNETS

for maximum energy . . . minimum size

With Crucible alnico magnets you get *consistently higher* energy product . . . which means *more* energy from a *smaller* magnet.

That's why they provide maximum design freedom for manufacturers of watt-hour meters, voltmeters, and devices of all kinds requiring magnets from 0.2 ounces to several hundred pounds.

Crucible has been a leading producer of these powerful magnets ever since alnico alloys were first developed. And its magnet experience is backed by over a half-century of *special purpose* steelmaking.

For technical assistance in solving magnet applications, call Crucible. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

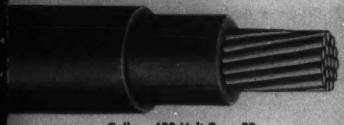
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

COLLYER for dielectric strength

Here's real proof of the dielectric strength of Collyer Standard Type RR Cable Suprene Insulation: after 14 months submersion in water at 50°C, Collyer Type RH-RW insulation (having a 3/64" wall thickness) tested 370 volts per mil.

Performance like this is engineered into every Collyer Cable, whether standard or built to special customer requirements.



Collyer 600 Volt Type RR

CHOOSE

Collyer

SUPRENE

(Rubber Insulated, Neoprene Jacketed)

COLLYER INSULATED WIRE CO.
245 Roosevelt Avenue, Pawtucket, R. I.

New Products

(*Continued from page 46A*)

to or extension of wire or cable facilities. Additional information is available from Motorola Communications and Electronics, Inc., Technical Information Center, 4501 West Augusta Boulevard, Chicago, Ill.

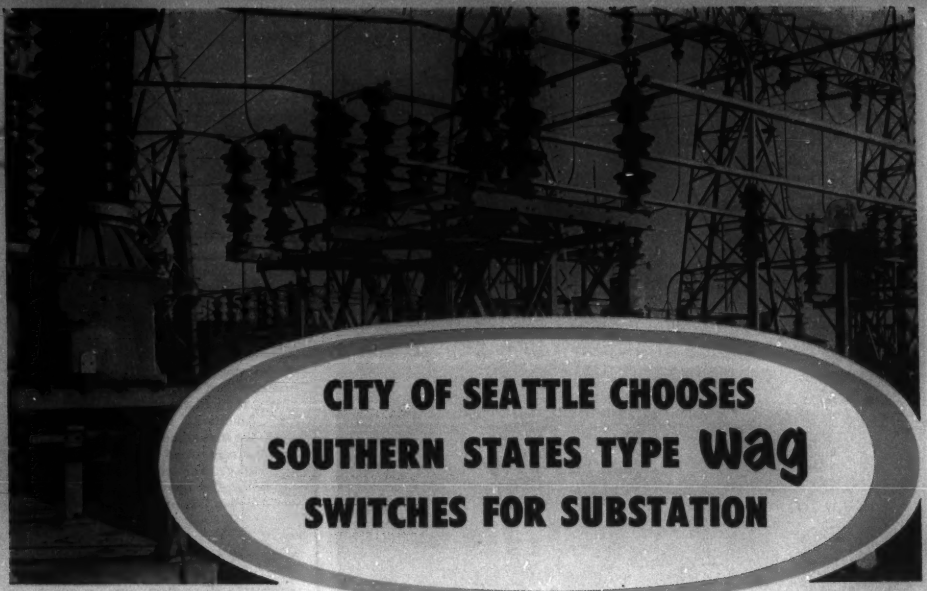
Geiger Counter Tube. A Norelco Geiger-counter tube, designed for X-ray spectrographic work involving elements such as phosphorus, silicon, and aluminum, has been announced by the Research and Control Instruments Division, North American Philips Company, Inc., 750 South Fulton Avenue, Mount Vernon, N. Y. Resolving time is approximately 150 microseconds. Threshold is approximately 800 volts. Slope of plateau is 10 per cent maximum, and end of plateau is over 1,100 volts. Slope depends on counting rate and electronic measuring circuits. The 10 per cent figure is based on a rate of 100 counts per second at a sensitivity of 1 volt. Operating potential is 900 volts. Background with 2 inches of lead shielding is 75 counts per minute maximum. Operating temperature range is −55 C to +75 C. Life is unlimited by use. The Norelco Geiger-counter tube is filled with neon gas and is halogen quenched. It is 6 inches long, 1 inch in diameter, and weighs approximately 80 grams. Catalogue number for the new tube is *62030*.

Reflector Lamp. Westinghouse Electric Corporation has introduced a new reflector lamp rated at 1,000 watts which operates on a standard 120 volt-circuit. The new type *R-57* is designed for a rated life of 2,000 hours, and its initial light output is approximately 15,500 lumens.

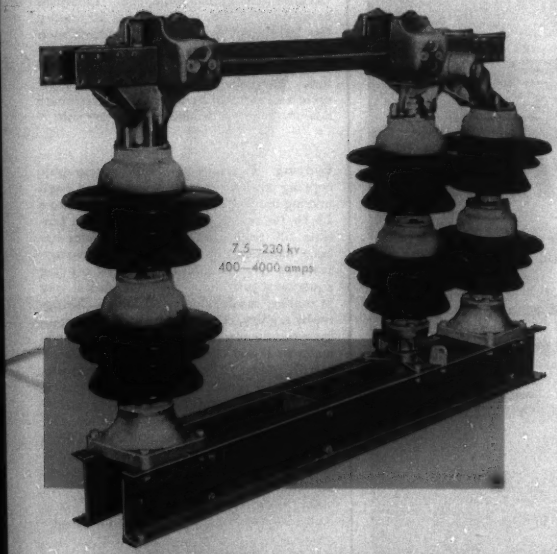
Secondary Capacitors. New 3- and 5-reactive kilovolt-ampere single-phase, 240-volt capacitors have been added to the capacitor line of the Line Material Company. The new units are designed for power factor correction on secondary distribution circuits. Over-all height of the new capacitors is 13 3/4 inches for the 3 reactive kilovolt-ampere, and 18 3/4 inches for the 5 reactive kilovolt-ampere. The new capacitors incorporate exclusive solderseal bushings and are equipped with two 48-inch insulated leads. For further information, write Line Material Company, Milwaukee 1, Wis.

Mechanical Motor Brake. The Cleveland Electric Motor Company has announced a new mechanical motor brake. It is built into the motor frame and enclosed in the housing, saving as much as 7 1/2 inches in length. Being mechanical in action, solonoids and coils are eliminated as well as costly maintenance. This new mechanical brake allows for quick opening and avoids sudden impact on stopping. Tension springs can be adjusted for rapid or slower stops. Four locking screws give any desired adjustment. Precise tolerances are not required with this new type brake. These new brake motors

(*Continued on page 50A*)



CITY OF SEATTLE CHOOSES SOUTHERN STATES TYPE Wag SWITCHES FOR SUBSTATION



One of the nation's outstanding municipals, the City of Seattle, Department of Lighting, chose a number of Southern States Type Wag Switches for its recently completed Shoreline Substation. Twelve three-pole 115 kv - 1200 amp switches are now in service. A second installation of Type Wag Switches, at another of the system's substations, will be completed soon.

Today, extra care must be given to the choice of air break switches, because increased generating capacity and a higher degree of integration bring corresponding increases in short circuit capacities.

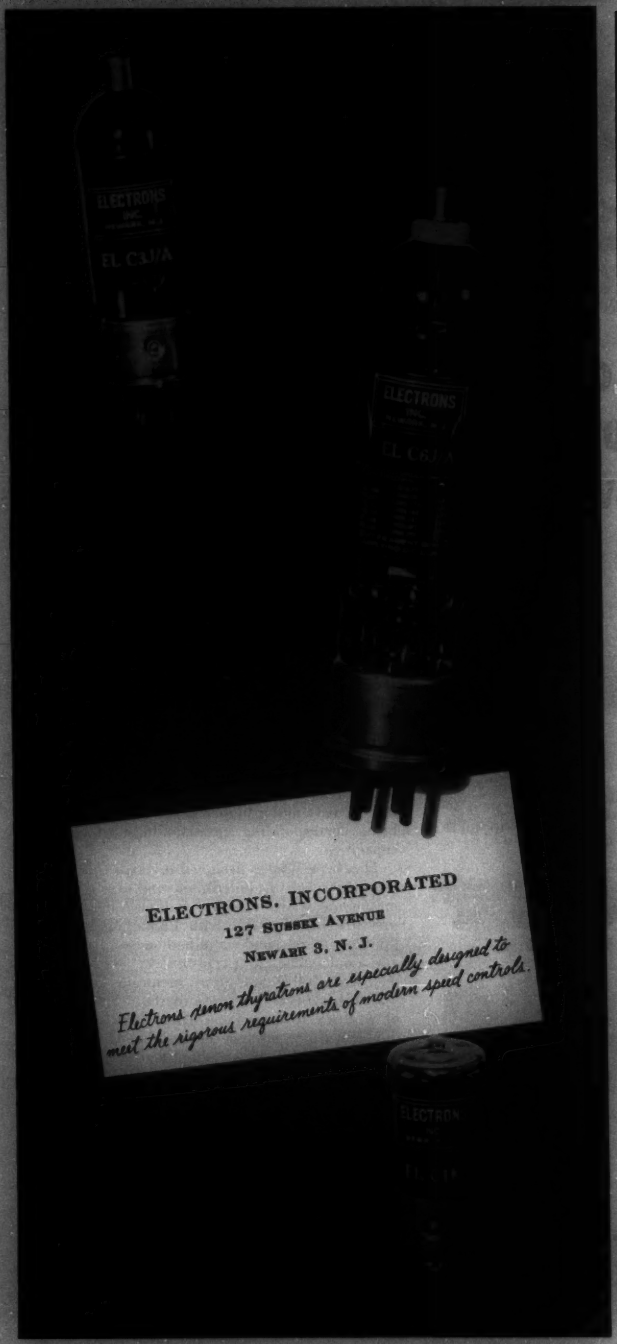
The Type Wag is designed to carry full-rated continuous current indefinitely and to withstand maximum short circuits. Self-cleaning, high pressure line contacts with greater deflection, shuntless design, and simplified mechanical linkage assure adequate performance—even under the most adverse conditions, including icing.

Other features that cause increasing numbers of utilities to use Type Wag Switches are: double-race, greaseless bronze ball bearings; oilite sleeve bearings; simplified design; no maintenance; and rugged, high-quality construction throughout.

Careful study will show why it will pay you to use Type Wag Switches. For additional details, write us for Bulletin 390-R.

SOUTHERN STATES EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto


ELECTRONS
ELECTRONS. INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
Electrons xenon thyratrons are especially designed to meet the rigorous requirements of modern speed controls.

New Products

(*Continued from page 48A*)

can be installed in any position and are designed especially for work requiring frequent braking. For more information, write to The Cleveland Electric Motor Company Department *MB*, 5213 Chester Avenue, Cleveland, Ohio.

New Motor Design. The Reuland Xpandable basic motor design permits many single-frame combinations of motors, brakes, fluid couplings, and gear reducers. This system saves money by buying and aligning separate units in tandem. These combinations are achieved through the use of standard, interchangeable Reuland assemblies and result in space-saving power packages. Alignment problems are eliminated and installation time is reduced through single-unit, "package" mounting. Purchasing and maintenance are streamlined, as well, by the single Reuland centralized supply and service responsibility. For engineering information and descriptive literature write to the Reuland Electric Company, Alhambra, Calif.

Resistance Analyzer. A resistance analyzer capable of accurately measuring the voltage coefficient of resistors over a variety of ranges from 1,000 ohms to 1,111 megohms to within 0.1 per cent, has been developed by the Electronics Division of The Kuljian Corporation, Philadelphia, Pa. Identified as model *KED-15*, this precision laboratory test instrument was designed to check such characteristics as d-c resistance, temperature coefficient, and voltage coefficient of resistors. The voltage coefficient of any resistor up to a capacity of 2 watts can be determined down to as low as 0.0002 per cent per volt.

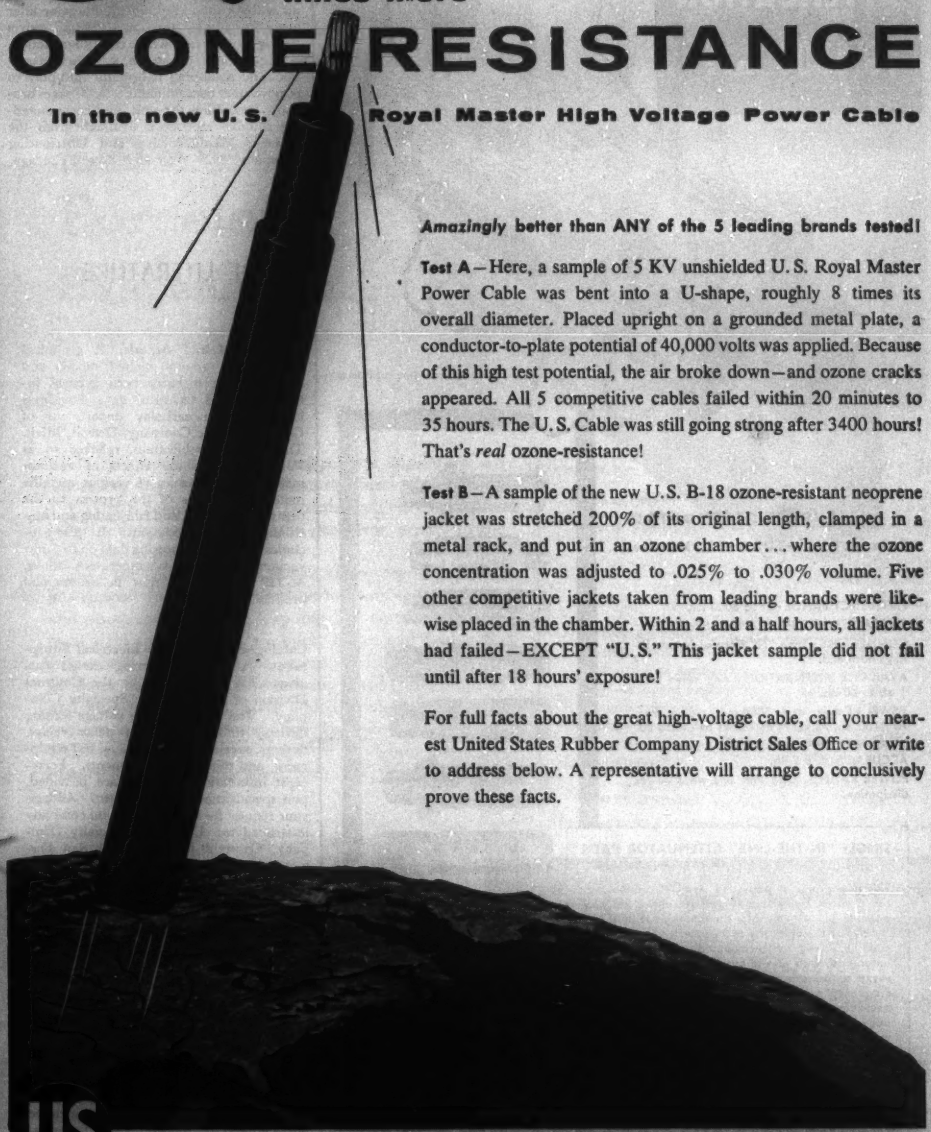
Copying Equipment. New xerographic copying equipment, which will reduce engineering drawings up to 24 by 36 inches onto a 12- by 18- inch paper master and make possible 100 copies in about five minutes has been announced by The Haloid Company. Haloid's new XeroX model *1218* copying equipment provides, a fast, economical way of making masters for duplicating. Xerography is a dry, electrical process requiring no intermediate negative. No sensitized papers, water or liquid chemicals are used. Use of XeroX model *1218* copying equipment permits use of precut rather than roll paper. Wet processing and hand shearing operations are eliminated. The reduced size and thinner paper save filing space as well as folding and unfolding time. The duplicated copies are clean and sharp, easy to read in the reduction. Detailed information may be obtained on request from The Haloid Company, 728 Bay Street, Toronto, Ont., Canada.

Compressed-Air Separator. An improved design of a compressed-air separator has been developed by Chicago Manufacturing and Distributing Company. The Textite air separator has effectively cleaned compressed air of water, oil, dirt, scale, cinders, and other

(*Continued on page 52A*)

97 times more OZONE RESISTANCE

In the new U. S. Royal Master High Voltage Power Cable



***Amazingly* better than ANY of the 5 leading brands tested!**

Test A—Here, a sample of 5 KV unshielded U. S. Royal Master Power Cable was bent into a U-shape, roughly 8 times its overall diameter. Placed upright on a grounded metal plate, a conductor-to-plate potential of 40,000 volts was applied. Because of this high test potential, the air broke down—and ozone cracks appeared. All 5 competitive cables failed within 20 minutes to 35 hours. The U. S. Cable was still going strong after 3400 hours! That's *real* ozone-resistance!

Test B—A sample of the new U. S. B-18 ozone-resistant neoprene jacket was stretched 200% of its original length, clamped in a metal rack, and put in an ozone chamber... where the ozone concentration was adjusted to .025% to .030% volume. Five other competitive jackets taken from leading brands were likewise placed in the chamber. Within 2 and a half hours, all jackets had failed—EXCEPT "U. S." This jacket sample did not fail until after 18 hours' exposure!

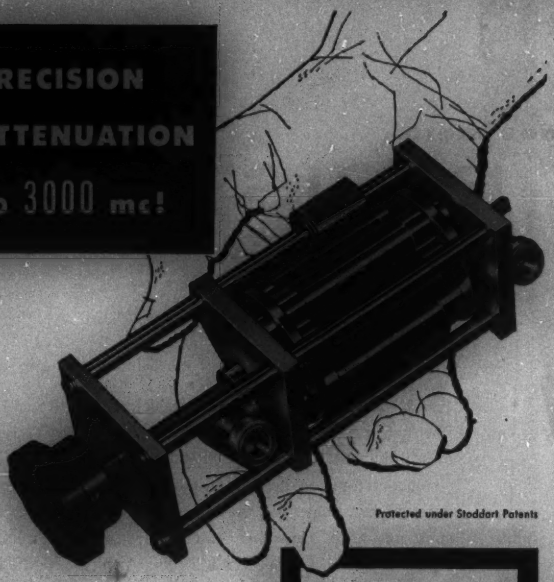
For full facts about the great high-voltage cable, call your nearest United States Rubber Company District Sales Office or write to address below. A representative will arrange to conclusively prove these facts.

US RUBBER

UNITED STATES RUBBER COMPANY

ELECTRICAL WIRE & CABLE DEPT. • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

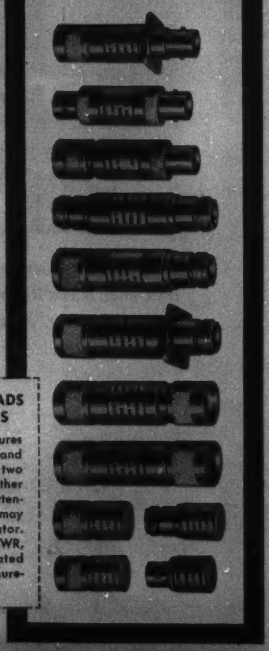
PRECISION ATTENUATION to 3000 mc!



Protected under Stoddart Patents

six-position
TURRET ATTENUATOR
featuring **PULL-TURN-PUSH** *action*

FREQUENCY RANGE: dc to 3000 mc.
CHARACTERISTIC IMPEDANCE: 50 ohms.
CONNECTORS: Type "N" Coaxial female fittings each end.
AVAILABLE ATTENUATION: Any value from 1 db to 60 db.
VSWR: 1.2 max., dc to 3000 mc/s, values from 10 to 60 db. As value decreases below 10 db, VSWR increases to not over 1.5.
ACCURACY: ± 0.5 db.
POWER RATING: One watt sine wave power dissipation.



SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATIONS

This new group of pads and terminations features the popular Type C and Type N connectors, and permits any conceivable combination of the two styles. For example, the two connector types, either male or female, can be mounted on the same attenuator pad, with or without flanges, so that it may serve as an adapter as well as an attenuator. Frequency range, impedance, attenuation, VSWR, accuracy and power rating are as designated above. Send for free bulletin entitled "Measurement of RF Attenuation."

STODDART AIRCRAFT RADIO Co., Inc.
[illegible] Hollywood 38, California • Hollywood 4-6262

New Products

(*Continued from page 50A*)

elements which are harmful to equipment wherever air is used. Through an arrangement of cleaning elements this separator removes unwanted by-products of compressed air without the aid of moving parts, or filter elements. Only the air stream moves throughout the unit where centrifugal action, jetting, sudden expansion, capillary attraction, and scrubbing is brought into play to remove the contaminants. A 4-page brochure describing the unit, and recommending suitable models, is available from the Chicago Manufacturing and Distributing Company, 1928 West 46th Street, Chicago, Ill.

TRADE LITERATURE

Vacuum Melted Metals. A technical bulletin on vacuum melted metals and alloys, which includes both general information and technical data, has been issued by the carboloy department of General Electric Company, Detroit, Mich. The 23-page publication, referred to as *VM-101*, covers the effects of vacuum melting on properties of various metallic materials, benefits of the process to the user of such metals, and fabricating and machining recommendations. It also includes detailed engineering data on two new vacuum melted high-temperature alloys, *M-252* and *J-1570*, now in commercial production.

Catalogue on Airborne Electrical Equipment. A new engineering design catalogue has been issued by the Contract Division of the Electronic Specialty Company. The catalogue lists voltage sensing devices, timers and time delay relays, flashers, special aircraft devices, test equipment, and miniature components. Forty-eight installation drawings are provided, plus specifications for each item. Address your request for this catalogue on company letterhead to: Electronic Specialty Company, Contract Division, 5121 San Fernando Road, Los Angeles, Calif.

Occupational Safety Guide. The National Safety Council's 1955 Occupational Safety Services Guide provides company safety directors with a complete catalogue of accident prevention aids available from the Council. In the service guide, company safety men will find not only the tools they need to build their plant safety programs, but also the training aids available for instructing supervisors and workers. The 68-page guide provides a list of council periodicals, newsletters, and a complete library of technical and administrative publications covering all phases of occupational accident prevention. Information on the subjects covered in the basic and

(*Continued on page 56A*)

VICTOR "Know-How"...

Gives You Purified Porcelain Suspensions...

America's Finest

VICTOR NO. 924
(EEI-NEMA TDJ-52-5)
25,000 LB. SUSPENSION
INSULATOR

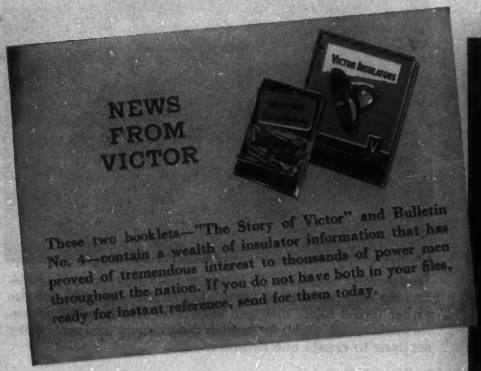
VICTOR *Purified* Porcelain suspension insulators are laboratory designed to make them the finest in their field. VICTOR'S complete testing facilities, which include the industry's most modern impulse generator, certify to the soundness of their design.

Take the 25,000 lb. unit shown above, for example. It has rugged, rounded corrugations for maximum strength and resistance to impact. Cap and ball bolt, built to the most rigid specifications, are thick, husky and double-dip galvanized to withstand the severe service for which this insulator was designed. Scientifically fitted glaze, properly and uniformly applied, gives added strength . . . added protection against contamination. Each insulator is proof-tested mechanically, then subjected to vigorous high frequency and 60-cycle flashover tests. You just can't buy a better suspension!

SPECIFICATIONS

60-cycle dry flashover	80 KV
60-cycle wet flashover	50 KV
Positive impulse flashover*	125 KV
Negative impulse flashover*	130 KV
Dry arcing distance	7¾"
Leakage distance	11"
M and E strength	25,000 lbs.
Impact rating	60 in. lbs.
RNI	50 Microvolts
1000 KC at applied	10 KV

*Crest KV. 1½ x 40 microsecond wave Critical Value.



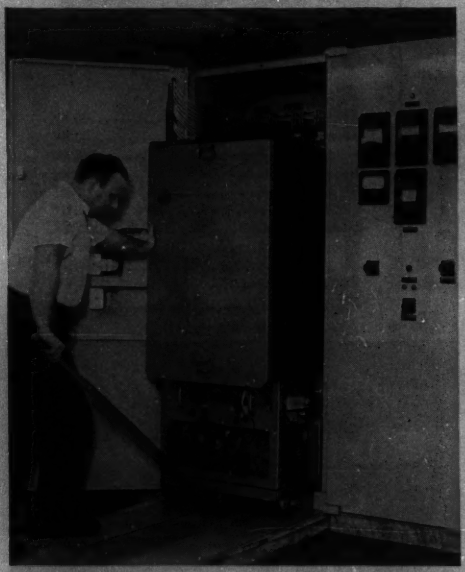
These two booklets—"The Story of Victor" and Bulletin No. 4—contain a wealth of insulator information that has proved of tremendous interest to thousands of power men throughout the nation. If you do not have both in your files, ready for instant reference, send for them today.

SPECIFY VICTOR
Purified Porcelain
Suspensions!

VICTOR INSULATORS DIVISION
I-T-E CIRCUIT BREAKER CO.
VICTOR, N. Y.

Low and High Voltage Pintypes • Suspensions • Guy Strains
Spools • Switch and Bus Insulators • Custom Designed Porcelain
Insulator Hardware

I-T-E, SINGLE SOURCE OF SUPPLY



Primary Section: Maximum protection on the primary side is assured with I-T-E Power Air Circuit Breakers. As an alternate to circuit breakers, roof bushings, throats, terminal chambers, oil cutouts, liquid disconnect switches or air interrupter switches may be furnished.

Transformer Section: I-T-E can supply any type of transformer required for a particular installation. It can be either liquid filled, nitrogen sealed, or dry type. All transformers match and line up with the primary and secondary sections to create one complete unit.

FOR COMPLETE UNIT SUBSTATIONS

Secondary Section: The secondary section consists of I-T-E switchgear. Completely interchangeable, horizontal drawout air circuit breakers are housed in a sturdy structure with completely isolated compartments, large rigidly braced bus, and a superior exterior finish.

You can buy a unit substation either of two ways: a piece at a time (the expensive way), or all at once (the economical way). I-T-E can sell you the individual elements, but recommends that substations be purchased complete, and from a single source of supply.

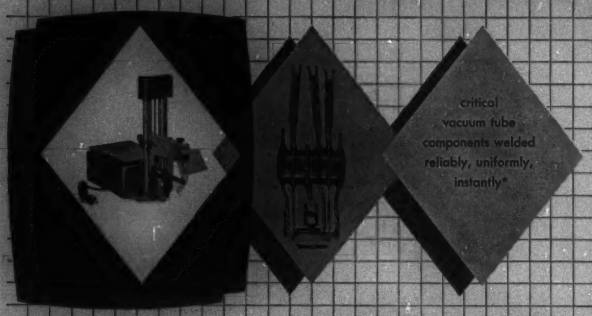
There are good, practical reasons for this. I-T-E's engineering assistance in over-all planning, floor layout, and choice of elements is more valuable to you when it covers the complete substation. Units are packaged and shipped ready to install without delay or complications.

There are further advantages in knowing that one dependable company stands behind your complete installation, and that all parts are designed to function as a unit.

I-T-E Primary and Secondary Unit Substations can be supplied for any application: indoor and outdoor, and in any standard rating. For details, contact the I-T-E sales office nearest you. Look in your classified directory under "Electric Equipment." I-T-E Circuit Breaker Company, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pennsylvania.

I-T-E CIRCUIT BREAKER COMPANY
Switchgear Division

STORED-ENERGY WELDING SPEEDS
VACUUM TUBE ASSEMBLY



WELDMATIC MODEL 1015 precision welder firmly joins wires, sheets and blocks of tungsten, nickel, nichrome, steel, silver and copper in tube element assembly for mass spectrograph guns. Molybdenum and tantalum also welded in plate assemblies.

*Made by Consolidated Engineering

Unitek WELDMATIC

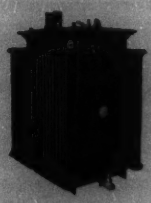
UNITEK CORPORATION
267 Halstead Avenue • Pasadena 8, California
Write for complete Technical Information on Stored-Energy Welding

engineers of leading industries are specifying

Courtesy Newark Evening News
South front of beautiful, ultra-modern office section of new Ford plant at Mahwah, N. J.

Marcus TRANSFORMERS

Marcus Transformers installed for lighting distribution in new Ford plants near San Jose, California, Louisville, Kentucky, and Mahwah, New Jersey as part of the Ford Motor Company's huge coast-to-coast multimillion dollar expansion program.



"Mark of Quality"

MTC

MARCUS TRANSFORMER CO., INC.
RAHWAY, NEW JERSEY

Representatives in Principal Cities

Trade Literature

(*Continued from page 52A*)

advanced courses of the Council's Safety Training Institute also is included. To assist the foreman, the service guide offers a monthly magazine, training films that show supervisors how to use basic human traits in building a better safety program, and several hundred made-to-order 5-minute safety talks. A full line of posters, films, and booklets are available to sell safety to the man on the job. Individual copies of Service Guide *2.1* may be obtained, without cost, by writing the National Safety Council, 425 North Michigan Avenue, Chicago, Ill.

Allied Radio's 1956 Catalogue. Allied Radio Corporation, Chicago, Ill., distributor of radio and electronic parts and equipment, has announced the release of their 1956 general catalogue. Reflecting the continuing growth of the industry, Allied's new 324-page catalogue lists more than 26,000 items. This 1956 buying guide may be obtained without charge by writing requests to Allied Radio Corporation, 100 North Western Avenue, Chicago, Ill.

Inland Testing Laboratories Brochure. Inland Testing Laboratories, 1457 Western Diversey Parkway, Chicago, Ill., has issued a 40-page brochure. It describes the qualifications, personnel, equipment, and facilities available at Inland for a wide range of products and systems, testing and evaluation, and other testing services.

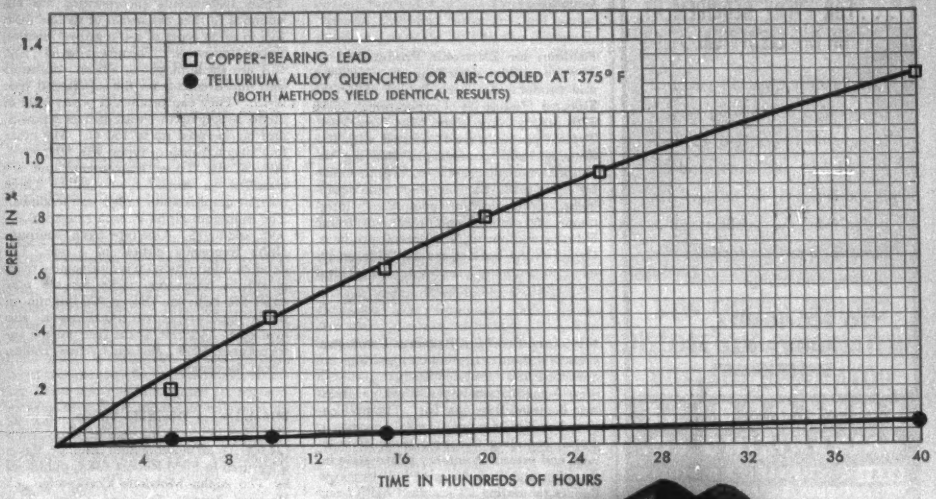
Leaflet on Step Regulator Ratings. A new approach to step regulator application as a possible solution to the load growth problem is contained in a leaflet entitled "How to Increase Step Regulator Ratings" released by Allis-Chalmers Manufacturing Company. The material shows how the losses of step regulators decrease as the tap changer moves closer to the neutral position, and how it is possible to increase current ratings when operating on these taps. Copies of this publication, *21R8317*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Load Tap Changing Equipment. A 16-page booklet on load tap changing equipment has been published by Pennsylvania Transformer Company, Canonsburg, Pa. The booklet deals with the company's Type *220* LTC equipment—the tap changing mechanism furnished on all Pennsylvania load tap changing transformers up to 7,500 kva, on 3-phase step voltage regulators up to 750 kva, and on all sizes of single circuit substations. Over 40 illustrations are used in detailing the construction, operation, and application of Pennsylvania's "load tap changers." Included is a section on control equipment, internal views of LTC transformers, and a brief outline of the methods of paralleling Pennsylvania LTC transformers. Copies of Pennsyl-

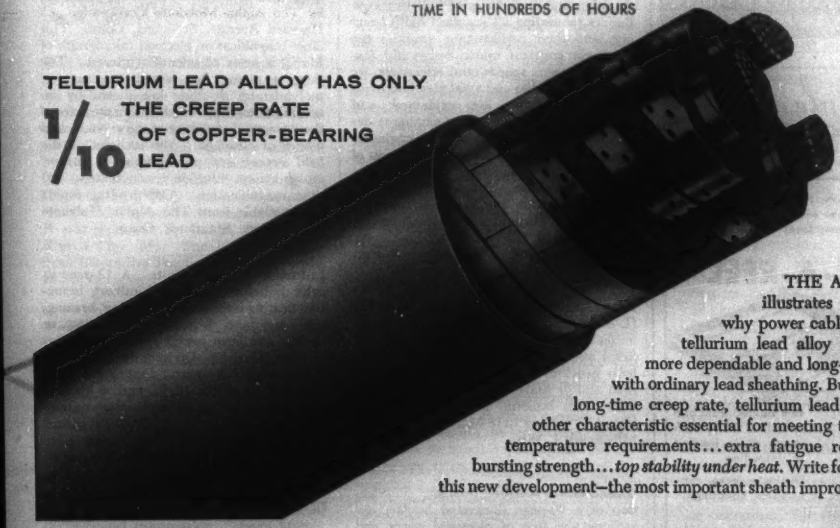
(*Continued on page 58A*)

ROEBLING PAPER POWER CABLE WITH TELLURIUM LEAD ALLOY SHEATH

CREEP OF TELLURIUM LEAD ALLOY AND OF COPPER-BEARING LEAD AT 200 PSI - 150° F



TELLURIUM LEAD ALLOY HAS ONLY 1/10 THE CREEP RATE OF COPPER-BEARING LEAD



THE ABOVE GRAPH illustrates one big reason why power cable with Roebling tellurium lead alloy sheath is vastly more dependable and long-lived than cable with ordinary lead sheathing. But besides its low long-time creep rate, tellurium lead alloy has every other characteristic essential for meeting today's load and temperature requirements... extra fatigue resistance... high bursting strength... *top stability under heat.* Write for full facts about this new development—the most important sheath improvement in years.

ROEBLING

Subsidiary of The Colorado Fuel and Iron Corporation

JOHN A. ROEBLING'S SONS CORPORATION, TRENTON 2, N. J. BRANCHES: ATLANTA, 934 AVON AVE. • BOSTON, 11-15 STILLING ST. • CHICAGO, 5525 W. ROOSEVELT RD. • CINCINNATI, 9253 FREDONIA AVE. • CLEVELAND, 19325 LAKEWOOD HEIGHTS BLVD. • DENVER, 4801 JACKSON ST. • DETROIT, 915 FISHER BLDG. • HOUSTON, 6216 NAVIGATION BLVD. • LOS ANGELES, 5340 E. HARBOR ST. • NEW YORK, 19 RECTOR ST. • ODESSA, TEXAS, 1920 E. 2ND ST. • PHILADELPHIA, 230 VINE ST. • PITTSBURGH, 1723 HENRY W. OLIVER BLDG. • SAN FRANCISCO, 1740 17TH ST. • SEATTLE, 900 1ST AVE. S. • TULSA, 321 N. CHEYENNE ST. • EXPORT SALES OFFICE, 19 RECTOR ST., NEW YORK 6, N. Y.

HOT DIP GALVANIZING

. . . FOR EVERY REQUIREMENT IN THE ELECTRICAL FIELD

Our Record: Over 50 years of progressive galvanizing service to manufacturers and fabricators of iron and steel products . . . any size or shape, any size order from the smallest to the largest. *Excellent facilities for pickling and oiling.*

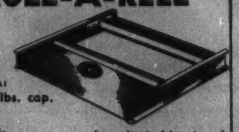
"TO ECONOMIZE, GALVANIZE AT ENTERPRISE"

ENTERPRISE GALVANIZING CO.
2521 E. CUMBERLAND STREET
PHILADELPHIA 25, PENNSYLVANIA

Simple as A B C

Handle heavy reels easily and safely; remove wire or cable from top or bottom, front or back of reel with

ROLL-A-REEL



Style A:
2,000 lbs. cap.
37.50
Style B:
4,000 lbs. cap.
75.00
F.O.B. Cincinnati

Low slanted front and positive front lock insure quick loading or unloading.

Eliminate jacks, cumbersome handling.

Carried easily to reels, job or storage.

WRITE FOR DETAILS

ROLL-A-REEL
1100 SYCAMORE AT CENTRAL PARKWAY
CINCINNATI 2, OHIO

Trade Literature

(*Continued from page 56A*)

vania Type *220* load tap changing equipment, Catalogue Number *5506*, may be obtained without cost by writing to Pennsylvania Transformer Company, Box 330, Canonsburg, Pa.

Facilities for Electronic Production. A 24-page booklet describing their facilities and products has been published by the Telectro Industries Corporation, 35-16 37th Street, Long Island City, New York. Typical products are illustrated with line drawings and photographs showing assemblies and subassemblies, aircraft industry equipment, recording and audio equipment, electronic test equipment, interphone and control equipment, electronic industry equipment, and special products. Copies of the booklet are available on request on company letterhead, to the Telectro Industries Corporation.

Miniature Precision Bearings Catalogue. Over 500 standard radial ball bearings are described and tabulated by bore size in a new 24-page catalogue published by Miniature Precision Bearings, Inc. The publication describes 16 types of radial bearings in detail, including two new series of bearings, and presents summary information on six other standard series of ball bearings. Besides tabulating all standard MPB bearings and their performance qualities the catalogue contains many design aid features. Torque, speeds, and tolerances are discussed. Radial and axial play and load-life characteristics are explained and graphically illustrated. The catalogue describes the company's many free engineering services, facilities for the production of special miniature ball bearings, and quality control procedures. The catalogue may be obtained without cost from Engineering Department, Miniature Precision Bearings, Inc., Keene, N. H.

Strain and Suspension Hardware Bulletin. A new Line Material Company (L-M) strain and suspension hardware bulletin lists the complete line of hardware items offered by L-M. The 44-page bulletin provides a brief description of each item and its usage, accompanied by drawings. This bulletin, *DL8A*, may be obtained by writing Line Material Company, Milwaukee 1, Wis.

United States Rubber Booklet. Publication of a 90-page illustrated booklet describing the line of electrical wires and cables manufactured for the railroad industry by United States Rubber Company, has been announced. Major sections of the booklet are devoted to insulation compounds, jacket compounds, signal cables, communication cables and power and control cables. Also included is a section on electrical tapes and splicing compounds, and several charts of information on messengers for aerial cables. Titled "U. S. Electrical Wires and Cables for the Railroad Industry," it is available to the trade from the electrical wire and cable department, United States Rubber Company, 1230 Avenue of the Americas, New York, N. Y.

Texas Instruments Transistors Bulletin. Texas Instruments Incorporated has announced further expansion of its line from five to seven types of n-p-n grown junction silicon transistors. The new types *951*, *952*, *953* are medium power silicon transistors and improvements on the superseded type *X-15*. They can produce a power gain of 30 db, supply up to 1 watt of class *B* power, and be operated up to 150 C. The other four silicon transistor types, *903*, *904*, *904A*, *905*, in the Texas Instruments line are classified as small signal units. Three current amplification ranges are available. The minimum alpha in each range is 0.90, 0.95, and 0.975. One type has a minimum alpha frequency cut-off of 8 mc. For detailed information on the three new types of silicon transistors, write for the new series *950* bulletin. Series *900* bulletin on small signal types of transistors is also available. Address Texas Instruments Incorporated, 6000 Lemmon Avenue, Dallas, Texas, for copies.

Molybdenum Disulfide Flakes. A magnification electron microscope photograph (24,000:1) of molybdenum disulfide flakes is featured in Field Report *138A*, published by The Alpha Molykote Corporation, 65 Harvard Avenue, Stamford, Conn. This large magnification electron micrograph of MoS_2, is news of scientific interest. The theories about the crystal structure of molybdenum disulfide are shown by an actual photograph which shows particles of the hexagonal structure of the crystals, and planes of cleavage. Also included in the field report are photographs of various molybdenum disulfide products at a 200 times magnification. Copies of this report are available from The Alpha Molykote Corporation, Stamford, Conn.

Induction Heating Units. A 12-page 2-color bulletin describing Lindberg induction heating units for heat treating, brazing, soldering, and heating for forming or forging has been issued by the High-Frequency Heating Division of Lindberg Engineering Company. Descriptions and technical data on 5, 10, 25, and 50 kw sizes are listed. Included are water systems diagrams, and a discussion of standard accessory equipment. For a copy of bulletin *1441* write High Frequency Heating Division, Lindberg Engineering Company, 2444 West Hubbard Street, Chicago, Ill.

Magnetic Data Storage Device. The TapeDrum, a new type magnetic storage device which combines the advantages of a magnetic drum and tape recorder, is described in a folder now available from Brush Electronics Company, 3405 Perkins Avenue, Cleveland, Ohio. Rapid access time and large storage capacity at reasonable cost are the outstanding features of the instrument. Principal applications are in

the fields of inventory control, data reduction, trend recording, and table storage.

Publication on Precision Cleaning and Finishing. American Wheelabrator and Equipment Corporation, 1744 South Byrkit Street, Mishawaka, Ind., has published a quarterly brochure on the subject of precision cleaning and finishing. It deals with the wet abrasive blast cleaning process. The first issue contains a discussion of the scope of the wet blasting process and the diversity of applications that it is capable of serving. Other subjects will be covered in forthcoming issues. American Wheelabrator and Equipment Corporation, will put persons on its mailing list for this publication, upon request.

Triad Transformer Catalogue. Two new Triad Transformer catalogues—general catalog *TR-55*, and Television Replacement Guide *TV-155* have been released by Triad Transformer Corporation. Catalogue *TR-55* lists 685 items, 79 of which are new to the line. The television replacement guide, *TV-155*, lists correct replacement transformers for television use, showing Triad items recommended for replacement in over 5,800 models of television receivers. Copies of these catalogues are available from Triad jobbers, or may be obtained by writing to Triad Transformer Corporation, 4055 Redwood Avenue, Venice, Calif.

Highway Safety Film. "The Perfect Crime," a dramatic new film treatment of the highway safety problem, has won one of the top honors from the National Committee on Films for Safety. The film is a 20½-minute, sound-color presentation by Caterpillar Tractor Company in conjunction with the National Safety Council's Construction Section and members of the Associated General Contractors of America. It was produced by Calvin Company of Kansas City, Mo. The film is available from Caterpillar Tractor Company, Peoria, Ill., or the nearest Caterpillar dealer.

Molybdenum Data. A compilation of technical and fabricating data on arc-cast molybdenum is presented in a 72-page booklet published by Climax Molybdenum Company. Titled "Arc-Cast Molybdenum and Its Alloys," this booklet covers, in addition to high temperature applications, numerous other uses for which the material has been proposed. Those interested in metallic molybdenum and molybdenum base alloys may obtain a copy of the booklet by writing to: Director of Technical Information, Climax Molybdenum Company, 500 Fifth Avenue, New York, N. Y.

Aircomatic Welding Equipment. The Air Reduction Sales Company has announced the availability of a new 16-page catalogue featuring Aircomatic (Airco's inert-gas-shielded metal arc welding process) welding equipment. Manual and automatic units along with accessory apparatus and welding wire are included in the illustrated booklet. A copy may be obtained by writing, Air Reduction Sales Company, 60 East 42d Street, New York, N. Y.

Bakelite Newsletter. Latest packaging developments and applications of plastics are summarized in a new illustrated newsletter for extruders, converters, and coaters published monthly by Bakelite Company, a Division of Union Carbide and Carbon Corporation. "Packaging with Plastics" presents case histories of successful packaging applications, technical data on basic resins, and new and unusual packaging ideas on the use of Bakelite plastics in the packaging field. "Packaging with Plastics" may be obtained by writing to Bakelite Company, a Division of Union Carbide and Carbon Corporation, 30 East 42d Street, New York 17, N. Y.

Drafting Equipment. A new 32-page, illustrated catalogue featuring a line of drafting equipment has been released by Frederick Post Company, 3650 North Avondale Avenue, Chicago, Ill. This literature provides a helpful buying guide for drafting machines, drawing boards, T-squares, parallel rules, triangles, templates, curves and lettering aids.

Tool Steels. Crucible Steel Company of America has announced the availability of a newly-revised 44-page book entitled "Tool Steels for the Non-Metallurgist." Written to present a practical understanding of tool steels without being overly technical, the text is confined to direct, familiar phrases. It is intended to familiarize the nonmetallurgist with the six basic classifications of tool steels. Properties of the various types of tool steels are discussed and general recommendations are made as to which type of application is most suitable for each classification. Copies of this booklet can be obtained by writing to the Advertising Department, Crucible Steel Company of America, Post Office Box 88, Pittsburgh 30, Pa.

Steelduct Catalogue. Steelduct electrical conduit production and helpful electrical building code data are featured in a 20-page catalogue published by The Steelduct Company, Youngstown, Ohio. Illustrated are the various rust-proofing and welding processes used in the manufacture of Steelduct electro-galvanized, hot-dipped galvanized, and enamel conduit. The booklet enumerates the series of production tests made on conduit and explains the use of various types of steel in making the company's product lines. This guide to weight and dimension data covers the firm's entire line of electrical conduit.

Core Form Power Units. Publication of an illustrated, 24-page booklet on core form power transformers has been announced by Pennsylvania Transformer Company. Both electrical and mechanical design, and construction features are described in detail. Copies of "Pennsylvania Core Form Power Transformers," catalogue *4455*, are available without charge from Pennsylvania Transformer Company, Canonsburg, Pa.

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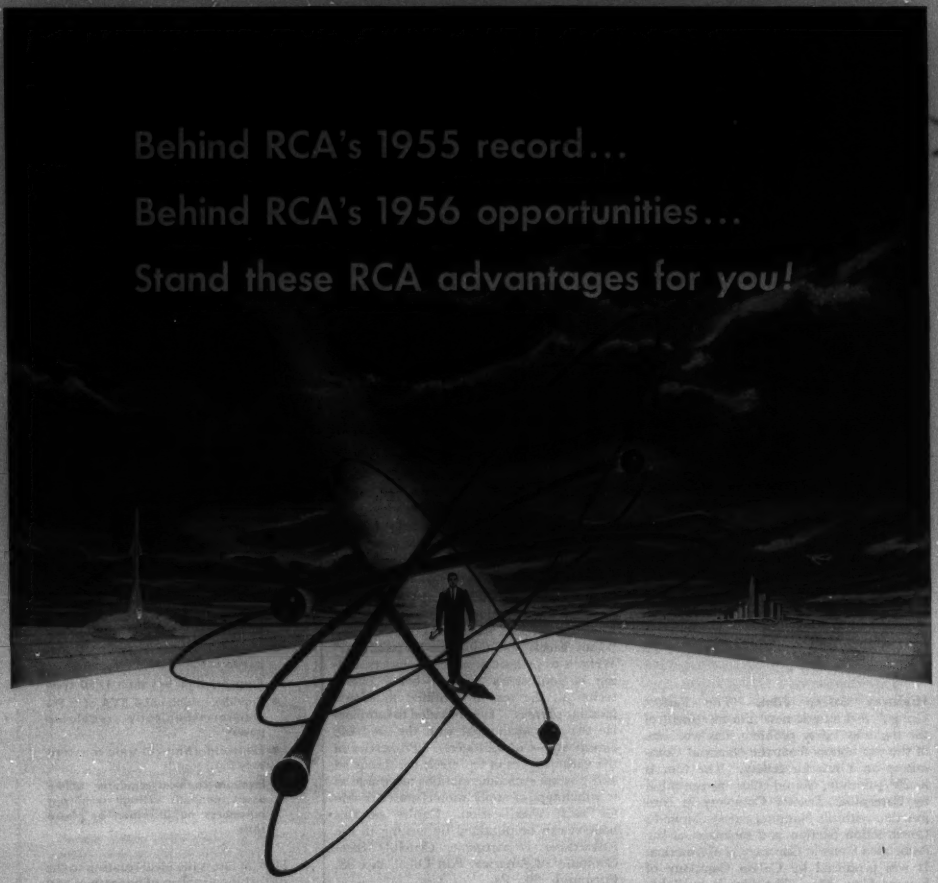

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